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THE VARIATION OF SOME CALIFORNIA PLANTS.

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(WITH NINE FIGURES)

I.

ONE of the first features of the flora of the mountainous and rather dry parts of California to impress one familiar with that of the eastern states and the Mississippi valley is the exceeding variability of a great many of the plants. While every botanist going into this field must have been struck by this fact, and some have remarked upon it, as JEPSON well does in the introduction to his *Botany of Middle Western California*, it has never been the subject of any particular study.

The good material for such work is practically unlimited; but my time has not been so, and it has seemed to me that the study of a few plants ought to show what is most characteristic of variation in this region. I have found that the study of these few has given me a plausible explanation of the great local variability, and at the same time has strengthened views already held as to the commonness of variation at other times in the history of plants beside their conception, and as to the generic homogeneity of continuous and discontinuous variation. Out of the material I have worked over, it will suffice for all purposes if I describe the variation of a few woody plants of wide occurrence, and of a few apparently monstrous ferns and the lesser variations connecting them with normal forms. The woody plants selected are several oaks growing near Palo Alto or Chico, and *Rhamnus californica*, *Arctostaphylos tomentosa*, *Ceano-*

thus sorediatus, and *Baccharis pilularis*, shrubs of the Palo Alto neighborhood, of frequent occurrence and reasonably independent as to altitude, soil, and exposure. As a further limitation, this account is confined with a single exception to the leaves of these plants; variation in other features—for instance in the scales of the cup of Quercus—is not less conspicuous.

QUERCUS CHRYSOLEPIS Liebmann.

The leaves of oaks are exceedingly variable everywhere, but the differences between the leaves of this species on the same tree, or on neighboring trees, are conspicuous even in such a genus. *Figs. 1–3*

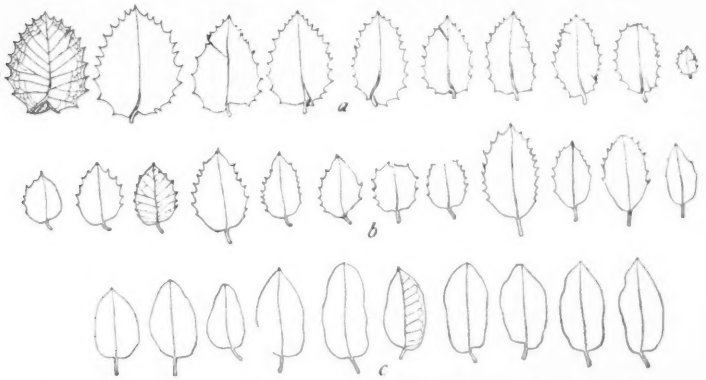

FIG. 1.—*Quercus chrysolepis: a*, alternate leaves on a branch; *b*, all the leaves on a twig; *c*, all the leaves on a twig. In all series from left to right is towards the apex.

are from neighboring trees, growing in the mountains back of Stanford University. Each tree had a well-defined leaf character, as these outlines, each representing leaves of one season's growth on one axis, indicate. The venation of the leaves on each tree was as characteristic as the outline. As a rule, older trees have more entire leaves, but this is not at all constant; all my specimens are from acorn-bearing trees. All the leaves figured grew on well-illuminated parts of the trees. In the three trees furnishing these leaves the variation in leaf-character was an attribute of the entire tree, and must therefore have occurred at a time in the tree's history when it or the stage in its ancestry where the variation occurred was a single cell, or (possibly)

at most a small and homogeneous group subject to a common impulse. We are in the habit of thinking of variations as concerning entire organisms.

More frequently, however, such leaf forms as these are not so strictly characteristic of whole trees; but single twigs show uniformly aberrant types of leaves; or most often single or few leaves of divergent forms are found scattered over the tree. *Fig. 2, a* represents the leaves of a single twig on which the leaf character changed profoundly during the season. This might have been ascribed to a change in the available water during the season, but that not all the twigs of the tree

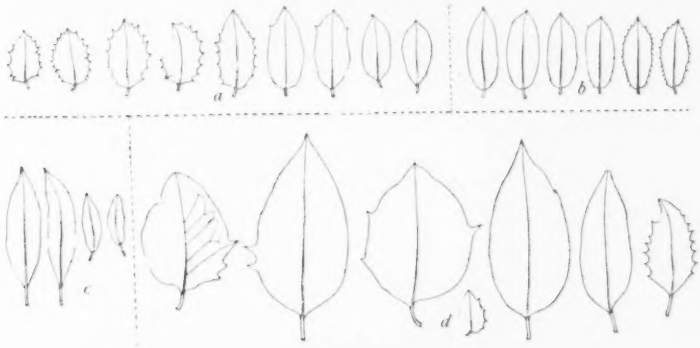

FIG. 2.—*Quercus chrysolepis: a*, all the leaves of a twig; *b*, younger leaves of a twig; *c*, consecutive leaves; *d*, some leaves on one season's growth of a twig.

behaved in this way. *Fig. 2, b* shows the opposite change in the same season's growth, on another specimen from Chico; and *fig. 2, c*, representing four successive leaves on one twig of the same tree, shows how abruptly the size, as a character of the twig, may change. *Fig. 2, d* shows outlines of a number of leaves on one season's growth of a twig; in this case variation seems to have occurred not in the apical meristem giving rise to both axis and leaf, but in the primordia of the individual leaves.

QUERCUS DUMOSA Nuttall.

All of the figured leaves of *Q. dumosa* were collected in a single small patch of chaparral, on exposed parts of mature shrubs; their differences are therefore independent of the environment. *Fig. 3, a–b* are all the leaves of the last season's growth on two twigs of the

same shrub, showing variation in the shape of the leaf as a character of the twig. *Fig. 3, c* shows single leaves from other parts of the same shrub, illustrating variation in single leaves. *Figs. 3, d, e* represent the characters of the shrubs as the varying entities; the shrub from which *fig. 3, d* was made bore conspicuously narrow leaves throughout, while *fig. 3, e* is from an example of the well-known bullate variety. This strain is so pronounced that it has been regarded as worthy of a distinct name; but it intergrades with the more typical form, and flat more or less spiny leaves are sometimes found on the same shrubs with the most bullate ones.

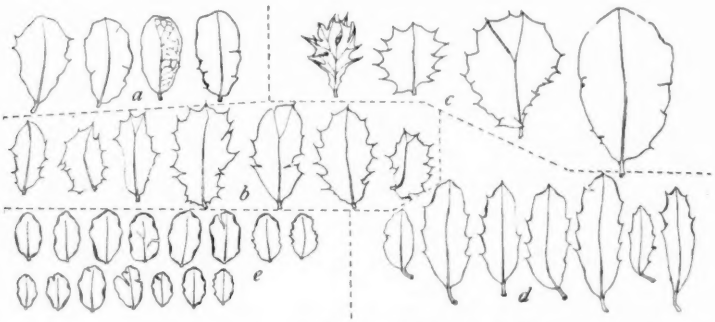

FIG. 3.—*Quercus dumosa: a*, all the leaves of a twig; *b*, all the leaves of a twig from same plant; *c*, single leaves from same plant; *d*, leaves of a twig of a bush with prevailing narrow leaves; *e*, leaves from the bullate variety.

QUERCUS WISLIZENI A. DC.

In the Santa Cruz peninsula *Q. Wislizeni* is a characteristic tree of the hilltops. In its typical situations it is less constantly and conspicuously variable in shape than the two species just considered. In protected spots it varies more noticeably, but as the influence of the environment may be directly expressed in these cases, they are left out of account. About Chico this is the common live oak of the valley, and is also common in the hills, and is as variable as *Q. chrysolepis* or *Q. dumosa* in that region. As in these, variation is by the tree, the branch or twig, or the single leaf. The difference between neighboring twigs on the same tree is illustrated by *fig. 4*.

Quercus agrifolia and other oaks.

Q. agrifolia Née is the commonest live oak of the valley and lower hills about Palo Alto. It varies in the shape, size, thickness, and pubescence of the leaves, and like all the preceding may be entire or very much toothed. Variation is by the tree or any part of it, but is by no means so extreme and chronic as in the oaks I have illustrated; in other words it breeds truer to a type. The other live oak of this region, *Q. multiflora*, is quite restricted as to its habitat; its variation is inconsiderable. Among the deciduous oaks, *Q. Kelloggii* Newberry, which is common in the foothills and mountains, is most variable in its foliage (and fruit); decidedly more so than *Q. lobata* Née, the great

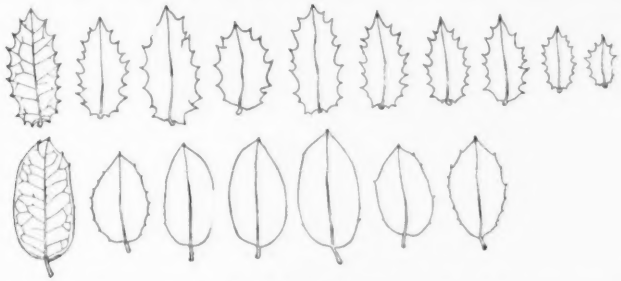

Fig. 4.—*Quercus Wislizeni:* all the leaves on two twigs of the same tree.

white oak of the valleys. In the mountainous north end of the state, *Q. Kelloggii* is still very variable, as is the *Q. Garryana* Dougl., found with it. On the slopes of Mt. Eddy, *Q. vaccinifolia* Kellogg, ranging from the foot of the mountain up in an extreme case to well above "timber line," has as variable leaves as *Q. chrysolepis*. The leaves of the small oak of the moist wooded valleys of this region, known as *Q. multiflora*, are very uniform in all respects; but quite unlike those of the *Q. multiflora* of the south.

In the cases of all these oaks the fact cannot be too strongly emphasized that I have been discussing only real variation, as independent of any influence of the environment as experiment could have made it. The influence of differences of environment, wherever they exist, is very evident, and has been broadly handled by Brenner.[1] He points out the great differences the environment causes

[1] Brenner, W., Klima und Blatt bei der Gattung Quercus. Flora **90**: 114–160. 1902; also Zur Entwickelungsgeschichte der Gattung Quercus, *idem* 466–470.

between the leaves of different trees, and even the leaves unequally exposed on the same tree; which naturally makes him skeptical of the value of determinations of extinct oaks by the remains of their leaves. The variations independent of the direct action of the environment, which I have just depicted, must strengthen the skepticism.

Before leaving the subject of Quercus I wish to discuss briefly BRENNER'S conclusions. He regards the less stability of the lobed forms of leaf as compared with the entire as evidence of the greater antiquity of the latter; such a difference in their *variability*—which should be a better test of newness than stability under varying environment—does not exist in this region. Still, considering oaks the world over, BRENNER may well be correct on this point. In his concluding paragraph, however, he exposes a classical weakness which needs pointing out as often as it occurs. It reads:

> Was als wichtigstes Ergebnis aus derartigen Untersuchungen hervorgehen dürfte, ist die so oft noch bezweifelte Thatsache, dass die durch äussere Medien hervorgerufenen Veränderungen an den Pflanzen thatsächlich erblich werden und im Lauf der Entwickelung zu eigentlichen Artmerkmalen sich entwickeln können. Durch den Nachweis, dass bei den Eichenblättern die Veränderungen beim Versuch und bei natürlichen Standortsunterschieden den mit dem Klima wechselnden Speziesverschiedenheiten entsprechen, hoffe ich einen Theil zur Kräftigung dieser Anschauung beigetragen zu haben.

If one accepts the inheritance of acquired characters *a priori* as "Thatsache," he may construe BRENNER'S observations as an illustration of it. But the direct reaction to the environment is fairly to be regarded as the result of natural selection, developed and preserved by virtue of its appropriateness; and since it is appropriate, it is obvious that by natural selection alone the plants varying in this direction spontaneously would be at an advantage, and in the long run would be parents of all the offspring. Since the identity of the forms assumed as a direct response to the environment with the forms characteristic of lands with the corresponding climate is fully explicable by natural selection alone, it is certainly no valid argument in favor of the inheritance of direct reactions to the environment.

My oak leaves will be discussed with those of the other woody plants.

Rhamnus californica Esch.

In the foothills and mountains back of Palo Alto, *R. californica* and its var. *tomentella* Brewer and Watson are scattered promiscuously and merge by insensible gradations. The distinctions are supposed to be that the variety has tomentose reddish twigs, leaves yellow or white tomentose beneath, and peduncles longer than the petioles. My material was not collected at a season to illustrate the last feature. As to the others, individual shrubs possess or want them, so that a collector might easily gather material of the type or the variety; but in the field there is no constant relation between the color of the stem and the tomentum on the leaf, and neither green nor red twigs are likely to be glabrous. The leaves also vary notably in outline, apex, thickness, and margin, and in the rolling back of the sides. The most remarkable variability is in thickness and texture, margin, and pubescence. I have measured the length, breadth, and length of petiole of all the leaves on one twig (one year's growth) of twenty-eight bushes. In the following table the results, averages for each bush, are arranged according to the shape of the leaves, the ratio of breadth to length, because this ratio is a feature that can be exactly expressed, and one that could not possibly have been considered in the collecting. This ratio is of average width to average length, and is usually larger than the average of the ratios for the individual plants.

Further explanation of the table is as follows: under "margin" *s* is serrate, *ss* subserrate, *e* entire; under "lower surface" *g* is green and apparently glabrous, *wg* pale green and moderately pubescent, *w* white (sometimes yellow) and very pubescent; under "reflex" is given the per cent. of leaf folded back when pressed fresh; under "stem" *g* is green, *rg* reddish-green, *r* reddish, *rr* red; thickness is stated in units of a spherometer.

The length of the petiole is not significant. The width of the leaves is omitted from the table because expressed in the shape; it is less variable than the length, wherefore the average length of the relatively narrow leaves (55.7^{cm}) is greater than that of the rounder ones (47.3^{cm}). I did not attempt greater accuracy of description of the margin than calling it entire, subserrate, or serrate. This placed a majority of the leaves in the middle class, which includes leaves with a few prominent teeth irregularly scattered or only near the apex, or few or more numerous closely appressed teeth, or rarely

TABLE I.

Shape	Length in mm	Margin	Lower surface	Reflex	Stem Color	Leaf thickness
1.8	25.4	*ss*	*w*	9	*r*	139
1.9	62.9	*ss*	*g*	0	*r*	102
	27.8	*e*	*wg*	2	*rg*	106
2.0						
	73.1	*s*	*g*	0	*g*	48
2.1	51.1	*ss*	*wg*	2	*rg*	93
	34.0	*e*	*wg*	20	*rg*	122
	30.3	*ss*	*w*	34	*r*	164
2.2	48.5	*e*	*w*	36	*g*	182
	70.8	*s*	*g*	0	*rr*	62
2.3	62.8	*ss*	*wg*	3	*rg*	89
	50.1	*ss*	*g*	13	*rr*	148
	47.0	*ss*	*g*	2	*rr*	102
2.4	50.0	*ss*	*w*	1	*r*	127
	29.0	*ss*	*wg*	17	*r*	118
	46.6	*s*	*g*	3	*rr*	100
2.5	43.5	*e*	*g*	17	*r*	118
	55.4	*ss*	*wg*	0	*rr*	178
2.6	50.0	*e*	*wg*	40	*rr*	126
	38.7	*e*	*wg*	33	*r*	149
2.7	114.6*	*s*	*g*	0	*g*	58
	35.7	*e*	*w*	25	*rr*	196
2.8	61.5	*ss*	*wg*	6	*r*	181
2.9	61.7	*ss*	*wg*	0	*r*	92
	46.7	*ss*	*wg*	1	*rr*	132
3.0						
3.1	58.0	*ss*	*wg*	3	*r*	134
3.2						
3.3	43.7*	*e*	*w*	20	*r*	174
3.4	66.5	*ss*	*wg*	24	*r*	154

very numerous very minute teeth, so small as to give the appearance of none at all. Various parts of subserrate leaves may be entire. I could have counted teeth and reached a quantitative expression of the serrateness of some leaves, but the entire parts of leaves and the great difference in the teeth made such data rather meaningless. As the lower surface is described, the majority again of course occupies the broad middle ground, but there is no tendency toward any particular part of it.

These specimens were all collected in the vicinity of Woodside (a post-office a few miles from Palo Alto), which avoided the chance of extending the apparent range of variation by introducing geographical varieties. Selection of extremes in any direction was also avoided, by such devices as choosing a bush at too long range to more than

recognize it.[2] Only the two starred in the table were collected after my attention was attracted to them by their many differences; they grew with interlacing branches in open ground by a roadside. No well-shaded bushes were chosen, nor shaded branches on the bush. While the immediate environment of the leaves was thus eliminated as a factor in making them different, the condition of the roots was left uncontrolled. I have no doubt that docking its roots would cause one of these shrubs to produce thicker, rounder, and more entire leaves, and I believe that these would tend to be pubescent beneath and rolled inward. But no visible differences in the ground were associated with the different variations. That the correlated variations are not common functions of any outside agent is evidenced too by their measure of independence—flat pubescent, entire green leaves, etc. The data in the table do not approach the range of variation of the individual leaves nor indicate the frequency with which the usually correlated variations are otherwise combined. The frequent correlation of thickness of leaf with pubescence, rolling backward, and evenness of margin might be due to such a combination of characters in heredity as many recent writers on inheritance assume; but I would rather ascribe it to mechanical factors which operate as the plant grows.

The range of the variability of this Rhamnus is not more remarkable than the absence of any well-defined type from which variation can be regarded as taking place; or, to express it in the usual way, in terms of curves, the curve representing any one of the varying characters under discussion would be conspicuously broad and low, without a well marked maximum and steep slopes. That this is true for the shape of the leaf the tabulated arrangement shows. If a curve were plotted with abscissae of 0.2, beginning with 1.7, the ordinates would be 1, 2, 5, 6, 5, 3, 2, 1, 2. If the length were plotted as a curve with abscissae of 1^{cm} (40 per cent. of the shortest leaf), the ordinates would be 3, 4, 6, 6, 5, 2, —1. If a curve were made to represent the thickness, with abscissae of 20 units of the spherometer (over 40 per cent. of the thinnest leaf), the ordinates would be 2,

[2] I have one branch of whose leaves the ratio of average length to average width is 4.25:1.00, but as I noticed its slender leaves before collecting it is not included in the table.

1, 3, 6, 6, 3, 3, 3; or if the abscissae represent 40 units, beginning with 40, the ordinates become 3, 9, 9, 6. The shape curves of variation of this plant must be clear from these three illustrations. Of course, the curve could be made steeper and narrower by increasing the value of the abscissal units; but by this process, if carried to an extreme, any curve can be reduced to a vertical line; and 40 per cent. of the shortest or thinnest leaf ought to be a large enough unit. The curves for the entireness of the margin and the pubescence of the lower surface would be of the same shape as these if there were scales by which they could be measured. These numbers are too few to make symmetrical curves, but as an objection to the validity of the conclusions this is largely removed by the fact that each number is an average of a considerable number of measurements.

ARCTOSTAPHYLOS TOMENTOSA Lindl.

This is the common manzanita of this region. Some authors have detected more than one species in what I include in it, but I am sure nobody would do so on my material. It was all collected in a limited region near the top of the mountain south of Woodside, using the same care to preclude the influence of local differences of environment as in collecting Rhamnus. Variable as it is, the manzanita has proved a much less favorable subject for this work than the Rhamnus, for several reasons. The most variable feature is the pubescence of both stems and leaves, and I have not found it feasible to measure this, because the chaff varies in size as well as in abundance, and is irregularly deciduous. Another difficulty is that the leaves formed at the ends of the seasons are smaller, narrower, and more entire than those typical of the plants; this made it necessary to discard some of the leaves, and to decide more or less arbitrarily where the typical leaves ceased on each axis. As this left too few leaves on each axis to furnish a safe average, I used all the fit leaves on the twigs of a small branch of each shrub. Tables II and III give the averages from thirteen plants, and the details of the individual leaves of one plant, to show their individual variability. The data under "margin" show the average number of teeth on each side of the leaf, and the average per cent. of the distance from base to apex at which the most apical tooth is found. Under base and apex their angles are given.

TABLE II.

Shape	Length	Margin		Base	Apex
		Teeth	Serrate %		
130	32.6mm	0.0	0.0	187.0	146.0
153	39.8	0.0	0.0	190.0	121.0
153	39.9	1.5	24.0	184.5	97.0
154	37.0	0.5	14.0	168.0	112.0
155	46.2	0.0	0.0	172.0	133.0
162	38.2	0.55	8.5	178.5	97.5
169	29.5	0.25	3.75	137.0	126.0
175	39.3	0.2	4.0	188.5	96.5
180	37.1	8.8	63.0	161.0	96.0
184	41.5	2.7	37.0	170.0	106.0
190	31.8	0.0	0.0	217.0	108.0
198	32.0	0.1	2.0	181.0	95.5
202	42.4	0.0	0.0	169.0	123.0

TABLE III.

Length	Width	Margin		Base	Apex
		Teeth	Serrate %		
40mm	27mm	4.0	50	175	90
46	25	2.0	25	165	120
43	28	4.0	80	195	120
46	24	5.0	30	165	90
47	23	1.0	15	165	95
47	28	3.0	30	195	120
30	19	13.0	85	150	90
45	23	0.5	10	165	130
39	21	1.0	30	180	115
41	22	3.0	50	150	90
48	25	2.0	55	150	90
40	21	2.0	30	170	75
31	18	0.0	0	155	120
42	23	2.0	20	150	105
40	21	1.0	20	180	100
43	22	4.0	45	160	100
42	24	3.0	60	165	120
35	17	0.5	10	135	135
34	19	0.0	0	165	120
46	23	1.0	25	165	120
41	20	2.0	25	150	95
38	22	5.0	60	180	100

Baccharis pilularis DC.

This is the most abundant shrub in the country about Palo Alto, growing practically everywhere. If *B. consanguinea* DC. is a distinct species, it does not grow here. The leaves (of *B. pilularis*) vary greatly from plant to plant, and also on the same plant. The size of the leaf varies on every plant with the order of the branch it is borne on; which made it so difficult to select a considerable number of leaves from different plants that as a whole should be fairly comparable that I did not try to make a table, but have preferred to reproduce the largest leaves from a few plants in a figure. *Fig.* 5 shows the largest leaf of each of seven plants. Of two of these

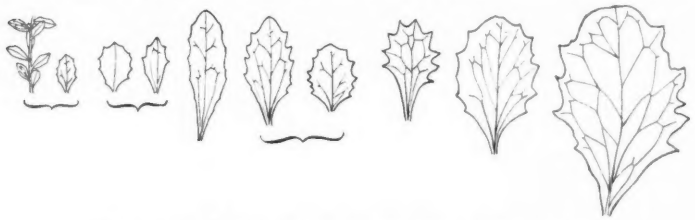

Fig. 5.—*Baccharis pilularis:* largest leaves of seven bushes.

plants two leaves each are drawn, to show the difference in shape. Of these seven, the most exceptionally large leaf, on its own plant was the smallest of the lot, the most of the leaves on that plant being like those on the twig figured.

Ceanothus sorediatus H. & A.

The two commonest and most ubiquitous species of this genus about Palo Alto are *C. sorediatus* H. & A. and *C. cuneatus* Nutt. The latter is the common one of the valley and is rather the more variable, but I have not material to illustrate its variation in any one place. The plants of *C. sorediatus* from which *fig. 6, a* was made were collected in a small patch more than half-way up the mountain south of Woodside. Each leaf drawn was the largest on its branch. Beside the difference in size and shape, there is an uninterrupted variation, which my figure only suggests, from the dentate form, which I suppose gives the species its name, to one with quite entire leaves; and variation on the individual plants as well as between them.

Why are very variable plants common in this region? Because of the great local range in environments. There is a very strong probability that the offspring of a plant in the level east will grow under substantially the same conditions under which its parent grew, and that this will be true generation after generation. Under such conditions, variations fitting the plant in the slightest degree to its environment will in time be selected and will become specific characters. That even the most minor differences which serve as specific or even as varietal characters have the selection value this assumes I have not the least doubt; for they surely are not there to distinguish the species, nor for the sake of uniformity. It is heredity, acting within bounds established by the rigor of natural selection, that limits variation everywhere. In the mountains of the eastern states conditions are in most places hardly less uniform than in the great valleys; the seed may be carried as far as possible, but the seedlings will grow under conditions like those of their parents.

When one of these Californian shrubs or trees scatters its seed, there is a strong probability that the plants which grow from some of them will find themselves in surroundings decidedly different from those of their parents. Soils differ more in new and mountainous than in old and level countries. A difference of some 2000 feet in altitude, with a corresponding difference in temperature, is possible among the offspring of any one of these plants; and these are but minor differences in environment, the moisture and wind factors being the important ones. Some of the descendants of one of these plants may start to grow on high ridges swept by ocean gales; others on lower, only less windy, very dry and hot ridges and hilltops; others in the chaparral, dry and hot, but protected from wind; others in the fog-soaked passes, sheltered from most winds; and still others in the cañons, or rather gulches, deep and shady enough to keep the air fairly moist and still at all times.

If a plant grew in this region whose lack of variation enabled it to produce offspring uniformly well adapted to any one environment a large part of its seeds would be likely to fall where the seedlings must start to grow under conditions for which they were but ill suited; while a variable plant growing here has some chance that its offspring, wherever they find themselves, will be more or less at

home. Since they all produce seed far in excess of what can grow, this means that in time the descendants of a variable plant will be found in considerable numbers under very different conditions; and that in this way it will be able to have many more descendants than the non-varying plant, the space available to whose offspring is limited. More descendants bear more seed, likewise variable, and with that they will thrive wherever they fall. And so the variable plant has some advantage in competition with the specialized one even where the latter is at home.

Where the environment is uniform over great areas, then natural selection breeds very close to a type, and considerable variation is a disadvantage; but where there are great and constant local differences in environment the premium is taken off of specialization, and natural selection favors a relatively high degree of variability. In such a place we find not merely that plants vary with the environment, but that in any single spot the individuals vary conspicuously as well.

If this is the real explanation of the variability of these plants, it is to be anticipated that plants of restricted range and characteristic habitat in this same locality will be more specifically adapted to their particular habitats, and when growing side by side with the ubiquists will be less variable. I have already pointed out that this is true among the oaks. The only other Rhamnus of this neighborhood, *R. crocea*, is not abundant enough even in spots to prove anything. In each of the other genera I have used, Arctostaphylos, Baccharis, and Ceanothus, we have other species of relatively local occurrence and relatively limited variability.

Baccharis viminea DC. is a plant of local occurrence on the flank of the mountains. Its leaves are sometimes entire, at other times sparsely serrate toward the apex; otherwise it is very constant. *Arctostaphylos Andersonii* Gray grows only near the mountain tops in the fog belt. The following measurements are of five plants selected in the field to show the extremes of variation; twenty-seven plants selected as were those of *A. tomentosa* would probably have varied less widely than these five do. No entire leaves were found.

Shape:	161,	169,	200,	203,	207
Length:	35.5,	44,	54,	46,	41.9
Serration %:	18,	76,	29,	36,	29

Ceanothus papillosus T. & G. is strictly confined to ridges in the fog belt, and is correspondingly constant. *C. thyrsiflorus* Esch. comes farther down the mountains, but not to their foot, and avoids exposed situations. The subjects of *fig. 6, b* were collected in the same place with those of *fig. 6, a*, at the same time and in the same way, before I realized that there was a difference in the variability of the two species, or suspected the reason for it. The contrast of the two is very striking.

II.

Some time ago I published a very brief note[3] on some freak ferns found in West Virginia, and suggested at the same time the interest of such freaks when the relation of minor and more conspicuous

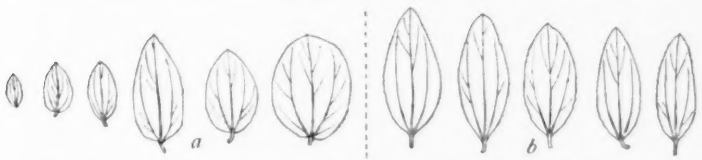

FIG. 6.—*a, Ceanothus sorediatus:* largest leaves of six shrubs. *b, C. thyrsiflorus:* largest leaves of five shrubs.

variations was being vigorously disputed. Since that time the mutation theory has lost none of its interest and probably none of its prestige. Meantime I have collected many more freak ferns, and some very full series illustrating less unusual variations; of these as many are presented here as seem necessary to justify the view that ordinary variations are indefinite in range and that extremes of series of such variations would be regarded as sports or mutations if found or collected alone. A detailed argument on this point with each fern shown would be superfluous. As in the former paper, I rely on figures rather than words to describe some of these ferns.

The variation in the extent to which some ferns are serrate, pinnatifid, or pinnate is very familiar. *Aspidium munitum* Kaulf. is usually only moderately serrate, like *fig. 7, b*. It varies in one direction to a form with teeth so closely appressed that at a distance it appears entire, and in the other to a form with compound teeth,

[3] BOT. GAZ. **34**: 142–144. 1902.

incised more than a third of the way to the midrib. *A. aculeatum* Swtz., in several varieties endowed with names, but freely merging, varies from a form but little deeper cleft than the most incised form of *A. munitum* to one in which these teeth become pinnae which in turn are cleft to the midrib into toothed divisions; that is, it varies from pinnate to tripinnate, the most divided part of fertile fronds being considered in every case. This variation could be duplicated in many ferns. It is doubtless continuous; but many of our fern species are founded on differences so small that a series of them would not bridge the gap between the extremes of this variation.

FIG. 7.—*Aspidium munitum:* teeth from six fronds, all drawn to same scale.

Fig. 8 is a fragment of a very abnormal frond of *A. argutum* Kaulf. Such freaks are not exceedingly rare. Some pinnae are usually normally developed, and there are all stages between these and mere lumps marking the place where pinnae should be. These freaks are almost always sterile, as other very abnormal ferns are likely to be. Reproduction is the consummation of normal development, and any deviation from the usual course is likely not to lead to this end. Of course, this is not true of ferns alone. I have found sterile freaks of a number of flowering plants among fertile normal forms. Reproduction demands a decidedly more perfect concatenation of favorable external and internal conditions than does growth.

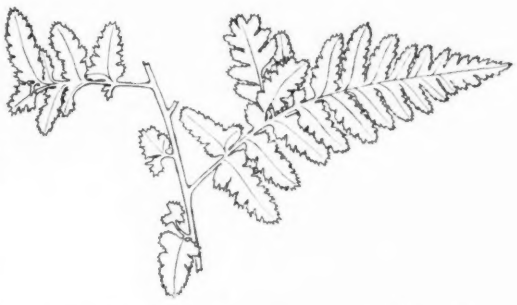

FIG. 8.—*Aspidium argutum:* part of abnormal frond.

There are several different lines of interesting variation of *Polypodium californicum* Kaulf. One of these is the elongation of the pinnae, some or all of them, on a frond. Fronds noticeably more acute than the normal are not rare, but of course the more extreme variations are proportionately seldom found. I have some twice as long as the normal; but none so conspicuous in this respect as the *P. vulgare* from West Virginia, in my other note on this subject. Another line is the increase in the size of the teeth and the deepening of the incisions between them until the pinna is pinnatifid, even to the midrib on the lower side. In this case the number of times the veins are forked is greatly increased, which disturbs one character often deemed specific in Polypodium; and the veins all remain free, which would be more notable if the separation of Goniophlebium as a distinct genus were natural. In merely serrate plants the union of the veins to form areolae of the Goniophlebium type may or may not occur, the anastomosis or its failure being utterly without rule, even on single fronds or single pinnae.

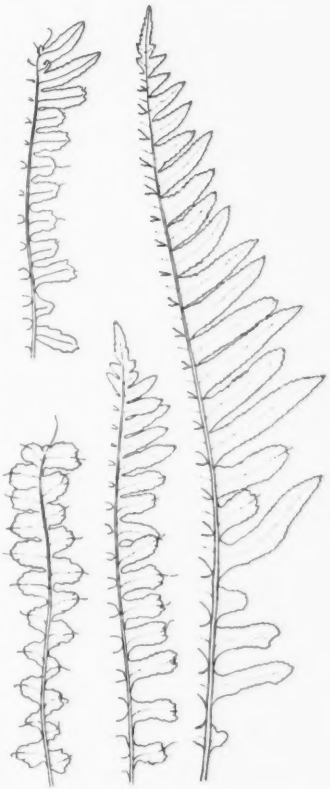

FIG. 9.—*Polypodium californicum:* a series of abnormal fronds.

The anastomosis is likewise irregular in the fern known as *P. Scouleri* Hook. & Grev., which is so unstable in other respects that it would as well be considered a form of *P. californicum*. Down close to the beach, where the typical form of *P. Scouleri* is found, it is variable, there being from three to twelve pairs of pinnae, which are "typically" twisted and thrown forward until they all fold in pressing, but are sometimes perfectly plane. Where more protected

they are thinner, with more acute pinnae. To what extent *P. Scouleri* represents the direct action of the environment, and to what extent it has developed into a really independent species can only be determined finally by experiment, but certainly it is very variable, and is also profoundly modified by the environment. Its variability is evidence on the point demonstrated by the oaks and shrubs.

A most remarkable monstrosity, many individuals of which have lost all characteristics of *P. californicum* and are indistinguishable from a freak of *P. vulgare* reported from Germany, was first found near Chico, where it had complete possession of a small patch of ground (*fig. 9*). Its essential feature is that the distal part of the midrib of the lateral pinnae and segments, and the whole axis of the terminal one, develop no wing, but spring free from the spore-bearing surface of the blade. In correlation with this, the growth of the segments is arrested, making their apices round and dentate, and the frond as a whole truncate-oblanceolate. The free part of the midrib may be prolonged to at least the natural length of the segment; or may be shorter, even to the extent of not springing free at all; in which case the development of the blade may be anywhere from very stunted to normal. All the pinnae may be affected; or some of them toward the apex may not; or only a few or a single one may be modified, making a complete series from normal fronds to the most monstrous. Since collecting it near Chico, I have twice found a few ferns like these back of Palo Alto, but in these only a part of the segments were ever malformed.

III.

I wish now to use this material, both the shrubs and the ferns, as the basis for a discussion of the "mutation theory" in bionomics. It is already clear enough that I do not believe there is any foundation at all for the view that mutations as essentially distinct from ordinary variations exist. That they do not I endeavor to show. But the mutation theory under one or another caption has for years been a refuge for those who on any ground regarded natural selection as inadequate to the demands upon it, and has recently been so powerfully supported by De Vries and others (Bateson, Wettstein, etc.), and has been so enthusiastically received that it has become

a proper subject for discussion by those who recognize no ground for it.

The mutation theory does not, as some of its supporters seem to believe, do away with the doctrine of natural selection. This doctrine is that among more living things than can live and bear progeny those best adapted to the existing environment will survive. It assumes, what is the fact, that the existing organisms differ. The mutation theory would explain the origin of the differences, saying that from their first appearance they are too wide and fundamental to fall in the category of "individual variations." The more prevalent idea since DARWIN has been that these minor, incessantly appearing differences were the raw material for nature to select among, and that by the constant survival of the individuals with the slightest advantages new races, varieties, and species might arise; but every partisan of natural selection recognizes variation as prerequisite to any evolution. The apparent issue is: "are the differences whose perpetuation gives rise to new species the ordinary individual variations, or the less usual but more considerable mutations?" But a question which should obviously be settled first is: "are individual variations and mutations distinct?"

Since I do not believe that the differences between the offspring of common parents differ fundamentally among themselves, it is but natural that I should be unable to frame a definition of a mutation which would really distinguish it from the general run of variations. For the most authoritative definition I have consulted DE VRIES'S *Mutationstheorie*. To my surprise, I have read the book, and then very carefully re-read the general part, without finding anywhere anything that has the force or form of a definition.

In the introduction, where "es sich darum handelt, den Unterschied der beiden Grundformen der Variabilität so klar wie möglich darzuthun," he says: "Die Mutationen sind Vorgänge, über deren Natur wir noch sehr wenig wissen. Die bekanntesten Beispielen solcher Mutationen sind die sogenannten spontanen Abänderungen ('single variations'), durch welche scharf unterschiedene neue Varietäten entstehen. Man nennt sie auch wohl Sprungvariationen" (p. 4). Again he says (p. 22): "Die letzteren [single variations] sind zufällige, spontane Abänderungen, unseren Mutationen *entsprechend*"

(italics mine). And (p. 23): "Die *single variations* sind zufällige, nur von Zeit zu Zeit auftretende, sprungweise die Formen verändernde Erscheinungen." He says (p. 5): "Die Gesetze der Mutabilität sind ganz andere als jene der Variabilität;" but this clue to the distinction fades when we read (p. 23) that "Die 'single variations' sind zufällige Erscheinungen, von deren Gesetzen man bis jetzt keine Erfahrung hat."

Calling single variations and saltatory variations and discontinuous variations synonymous with mutations does not tell what any of them are. The one criterion by which DE VRIES tries consistently to distinguish mutations is their giving rise to specific characteristics. This certainly does not admit of practical application, because we do not know how to identify a specific characteristic. It is a very tenable position at present that the species is a group of organisms with limits set by our convenience, and that many "valid" species—to put it moderately—are characterized by distinctions which are matters of degree. The specific characteristic can hardly be more clear-cut than the species it characterizes. If specific characteristics are in nature unstable and not exactly definable, this one means of identifying mutations is imaginary, in addition to being inapplicable. DE VRIES holds that species, not necessarily with the usually recognized limits, are definable and never have merged, and that their individual characteristics are likewise definable and stable; but when he identifies these in turn by their origin by mutation, he brings his argument into a circle.

The practical characteristic of mutations on which DE VRIES lays most emphasis is their inheritance: "Solche sind fast stets entweder völlig oder doch in hohem Grade erblich" (p. 16). But, as he of course recognizes, the continuous individual variations are also hereditary. We see that on every hand. The most familiar examples are furnished by human beings. DE VRIES says explicitly that the differences between them have not arisen by mutation as he uses the term. Yet what characteristic of any species is more certain to be inherited than the straight hair or the black hair of a pure Chinese, or the complexion of an Ethiopian or an American Indian? Among the much less constant features of our own race we know how likely the color of the eyes and hair, and other physical peculiari-

ties, and even mental eccentricities, are to be inherited. On the other hand, mutations are not always inherited, as DE VRIES's observations on Oenothera show; and if they were, there could be no mutations. Variations certainly differ in the reliability with which they are inherited; but mutations, if there were such, would not be distinguishable from other variations in this respect, unless sometimes in degree.

Many authors have sought to distinguish single variations or discontinuous variations from the continuous individual variations by the extent of the deviation from the parental type. DE VRIES does not lay himself liable on this point, saying explicitly that they are not distinguishable in this way (p. 41): "Die Betrachtung mancher *single variations* hat die Einsicht eingebürgert, dass die Mutationen jedesmal bedeutende Veränderungen sein müssen, namentlich, dass sie grösser sein sollten als die Variationen. Solches ist aber durchaus nicht der Fall, und anscheinend sind wenigstens zahlreiche Mutationen kleiner als die Unterscheide zwischen extremen Varianten."

If mutations cannot be recognized by their range of deviation, nor by their being inherited, from other variations which may chance to be unusually wide and to be hereditary, there is no test by which they can be recognized. If a practical definition of a mutation had ever been framed, it could not have escaped DE VRIES; and if his idea could be formulated so that it would represent a distinct phenomenon recognizable as such in nature, he would certainly have given it that form. I agree heartily with its friends in welcoming DE VRIES's work as the most valuable empirical contribution to our knowledge of the origin of novel forms of organisms since the *Origin of Species;* and that DE VRIES's method—the analysis of the composite character of a species into its elements, and the study of the origin (*and change*) of these—is far more rational and promising than the study of the "species," as we recognize them, as a whole. But I regard his mutations as generically different from ordinary variations, and his specific characteristics as distinct and clear-cut in their existence and abrupt in origin, as undefined and not scientifically definable, because not representing distinct natural phenomena.

DE VRIES's recognition that the discontinuity of "discontinuous" variations does not necessarily distinguish them from "continuous"

variations is one of the best evidences of his familiarity with the subject. Numerous writers ascribing to discontinuous variations the same importance he does to mutations have, as he says, regarded them as fundamentally distinct in the range of their deviation. Some of these writers have regarded their importance as a function of the extent to which they are aberrant. This question has been threshed over so thoroughly that I do not care to touch on it more than to suggest again the frequent sterility of sports. The assumed distinctness of discontinuous variations is, however, by no means so trite a subject.

I disbelieve in the distinctness of these two classes of variations on empirical ground, and *a priori*. We will consider the former first. If they are distinct, it must be possible to draw a line between them, and to say positively of any variation with which we are thoroughly familiar that it is the one or the other, and to give a reason for the judgment. It will be classed as discontinuous only when the series of less considerable variations in the same direction breaks short of it. But every first-hand worker in this field knows that such series always tend to fill when the material is increased. In variation within wide limits or limits approximately but not absolutely fixed, the extremes of any finite number of examples are likely to be disconnected. When the number is increased sufficiently the gaps fill up, but new isolated extremes are found. Do the variations which are assimilated to the regular curve in this way thereby become continuous? If "discontinuous" means anything, they do; and if they do, it obviously does not mean very much.

My abnormal ferns illustrate this assimilation of apparent monstrosities into a regular series with the accumulation of enough material. The Polypodium I described from West Virginia, with the apical segment and its neighbors greatly enlarged, seemed most remarkable when I first collected it; but a thorough search of the spot the next season showed a long series of specimens bridging the gap between these seeming monstrosities and typical plants. I have had the same experience with several lines of variation of *P. californicum*. In its extreme form the caudate monstrosity, with the frond as a whole narrowly oblanceolate, the individual segments abnormally broad and widening toward the round or retuse apex, and the midrib springing as a long curved hair from the dorsal surface, is the most extreme

freak fern I have ever seen. From its occurrence in compact patches I am sure it is as near as nature comes to a mutation in DE VRIES's sense. And yet, examining hundreds of specimens, I have found a very complete series of steps connecting it with typical plants. Does the fact that thorough search fills the series class this freak outside of discontinuous variations, where it would unhesitatingly be placed if I had done less hunting? What fern in the series is just aberrant enough so that if found alone it would constitute a mutation? An answer should be possible if mutations and variations are distinct.

Polypodium californicum with its veins all free exhibits variation not merely beyond the limits of the species, but beyond those of the subgenus.[4] That would be a mutation surely; but I have fronds of this kind and others with some anastomosing veins from the same rhizome; fronds with anastomosing veins on one side of the rachis and free on the other; and fronds with the two forms of venation variously distributed among the segments. Among the fungi I have a number of examples of extra-generic variations, as the genera are now limited; but the boundaries are so artificial or dubious that most of these have no certain interest at present. In a dozen or so American species of Puccinia, spores of the Uromyces type are common or at least known. In collections of Lenzites from a single log, I have specimens with many connected lamellae, and others with all of them free, which by themselves would unhesitatingly be referred to Agaricaceae, and still others strongly suggestive of Irpex.

It is hardly worth while to rehearse more instances in which mutations and ordinary variations cannot be distinguished; these few seem to me to prove the case as well as more would do it. If mutations and variations were fundamentally different, it would be possible to say of any one of these peculiar ferns that it belongs in one or the other category, and the more copious the material the easier it would be to apply the classification; if it were but natural. But the more thoroughly I have collected and examined them, the more evident it has become that the slight and extreme variations differ only in degree. I am quite aware that this evidence is not of the same kind as DE VRIES's, and that his has a value in the study of heredity which mine absolutely lacks.

[4] Goniophlebium was regarded as a distinct genus by BLUME, and is just now restored to that rank by UNDERWOOD.

My evidence is appropriate, however, to the question at issue. Irrespective of the individual parentage of the plants, it shows that the distinction between wide and narrow, or continuous and discontinuous, variations is artificial. That these aberrant forms should be the result of several generations tending in the same direction would be incomprehensible in view of the sterility of some of the forms and partial sterility of others; and would itself be contradictory to DE VRIES'S idea that new forms of plants arise suddenly, without preparation or intermediate steps.

The *a priori* objection to really discontinuous variation is the impossibility of really discontinuous development. Every organism that varies grows, and varies only as it grows. All organisms of any kind are indistinguishable during a considerable part of their development, but sooner or later their individual differences appear and become fixed. The tendency of heredity, as the conservative factor in both evolution and development, we believe is to postpone the appearance of deviations from the parent types. If they appear very late, the variations will be very small; if they appear earlier, they will obviously be more notable. If variations in growth appear much earlier than usual, the variation will be unusually profound. But it must be evident to anybody that it is not possible to select any point within the range of known deviation in the development of any organism whatever, and to say that the differences which occur before this time are different in kind from those which appear at and subsequent to it.

Variation, when it is just appearing, is a phenomenon involving small and homogeneous groups of cells; or, regarded in finer detail, single cells. When variation occurs it is by the unit of the varying structure. If it occurs early, the subsequent development of the units can make it become very conspicuous; but the variation *is* when it *is*, irrespective of later growth based on it. Stomata and trichomes are as a rule formed late in development, and the presence of two where one is normal is likely to escape our attention, as is the presence of an extra leaf on a tree; cotyledons are formed earlier, and an extra cotyledon, perhaps involving an unusual form of the whole plant that grows from the seedling, is an object of interest and remark. But when the first step toward the formation of the extra cotyledon was

taken it was certainly as small as can be imagined. And surely there is no point between the formation of an extra cotyledon and that of an added leaf on a season's growth where mutations leave off and variations begin. Both begin with the formation of two growing points from one. Every step in growth is an insensible move from the preceding state; and variation, inexorably dependent on growth for its appearance, cannot be less continuous than growth is.

It may be objected to this argument that the variation does not occur in growth, but before it begins; say in the formation of the germ cells. That cannot be demonstrated, even in as favorable subjects as the insects. And if it were really and demonstrably true, it would not damage the argument, but merely shift it. Life is an uninterrupted process from generation to generation. The division of the chromosomes, the reduction in their number, and their combination in the sexual union are orderly, regular processes, just as the growth of any individual is. In our ignorance of the forces at work and their way of working I can imagine no discontinuity in these finer, more recondite processes, any more than in more visible growth. Nor can I see why we should regard differences between twin organisms as not arising in growth because we suppose their environment to be identical, and on that ground refer the differences which we certainly do see to still earlier stages in ontogeny, perhaps even antedating fertilization; unless we can show differences in the environment there. It is perhaps natural to suppose that the things we do not understand happen in the stages we know least about, but this assumption does not share the nature of a proof. It is therefore sophistry to plead that variations are independent of growth as an objection to the principle that they must be as continuous as growth is.

If variation is a phenomenon of growth, it may occur wherever growth is going on. In the beginning of this paper I have pointed out that it actually does this in the oaks I studied. It is as reasonable to speak of variation localized in the parts of a tree, each the product of the activity of an isolated meristem, as to regard the differences between parthenogenetically produced offspring of a single parent as examples of it. KELLOGG has shown that variation is more considerable among the parthenogenetically than the bisexually produced members of a hive of bees.

SUMMARY.

In this part of California, where conditions are locally very diverse, plants are more variable congenitally than in regions where the environment is uniform. For in the latter, natural selection acts along the same line on many generations, and the more closely plants breed true to forms fitted to their uniform environment, the better are their chances of perpetuation; while here natural selection is unlikely to work in the same way on many generations of variable plants; and breeding very close to a form fitted to any one sort of environment decreases the number of the plant's prospective descendants.

For the same reason, the ubiquists in this region are more variable than the plants of restricted occurrence. Their variation enables them to be ubiquists, and being ubiquists keeps them variable.

"Mutations," or discontinuous variations, and the most insignificant of individual variations are parts of one unbroken series.

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KLINOSTATS AND CENTRIFUGES FOR PHYSIOLOGICAL RESEARCH.[1]

FREDERICK C. NEWCOMBE.

(WITH THREE FIGURES)

SOME years ago, when the author had to make use of the klinostat for extensive experimentation, the work went so slowly with one machine that means were sought to secure the operation of several klinostats at the same time without incurring the expense incident to the purchase of a number of the costly machines in common use. After some attempts to construct apparatus on too light and too cheap a scale, the apparatus here described was designed and manufactured with the cooperation of Mr. RALPH MILLER, at that time university mechanician. It has been used extensively for seven years, and has answered every demand made upon it. It is herewith described partly in response to several inquiries by men in other universities, and partly with the hope that it will be welcomed as offering a means for various kinds of research now practically impossible with the spring machines.

This apparatus can be provided with a horizontal and a vertical klinostat to run at the same time, the whole costing less than a Pfeffer machine; and the number of turn-tables can be increased almost indefinitely. Moreover, it will carry a much greater load than the spring klinostats.

I. CENTRIFUGES.

For both the centrifuges and klinostats the same motive power is used—an electric or a water motor. I have found it convenient to have both kinds of motors; for while the electric motor runs more evenly and with less noise, the current is more liable to interruption from one cause or another. Should one have the advantage of a constant head of water, secured by a tank with constant water level, as suggested by ARTHUR,[2] a water motor alone would suffice.

[1] Contribution 83 from the botanical laboratory of the University of Michigan.

[2] ARTHUR, Water power for botanical apparatus. Proc. Indiana Acad. Sci. 1897: 156.

By a series of pulleys on shafts, as shown in *fig. 1*, any desired speed of revolution can be secured. In the figure two centrifuges are shown for revolution on a horizontal axis. The centrifuge nearer the motor shows a large chamber fastened to the revolving plate, as already described from this laboratory by REED,[3] while the centrifuge at the right carries a plate of ordinary size—about 15^{cm} in diameter.

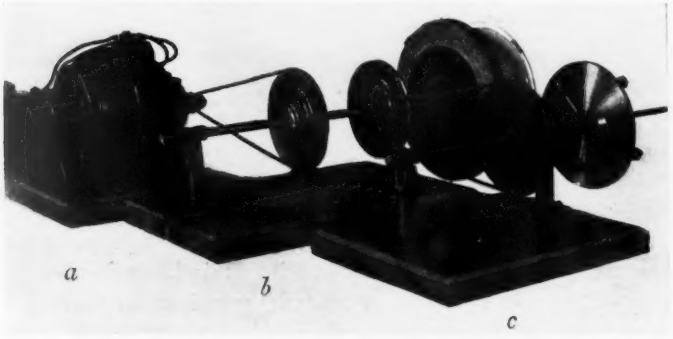

FIG. 1.—Electric motor (*a*) and two horizontal centrifuges (*b* and *c*).

II. THE KLINOSTATS.

The centrifuges of *fig. 1* are immediately turned into klinostats by the interposition of a worm reducing gear between the motor and the first shaft pulley. *Fig. 2* shows the apparatus set up for klinostat revolution; but in this figure, instead of the simple shafting with plate attached, as in *fig. 1*, we have a special form of klinostat shown, a form capable of revolution about either a vertical (*a*), a horizontal axis (*b*), or any oblique axis.

III. DESCRIPTIVE DETAILS.

The chief excellencies of this apparatus are found in what may be termed its unit construction, enabling an interchange of parts and an indefinite increase of turn-tables. The shafts are all the same diameter, the pulleys are interchangeable, and the shaft supports are all the same size.

[3] REED, A damp-chamber for use on the klinostat. Jour. Appl. Micros. **4**:1490. 1901.

The motors.—Instead of temporizing with cheap motors, it is better to purchase those of known efficiency at the outset. A one-fourth horse-power will do the work well. A constant water pressure or a constant electric current will demand only one motor. Neither of these sources of power being always constant at this university, I had to purchase both kinds of motors. The water motor is a Pelton $\frac{1}{4}$ HP with a water head of about 10^{m}. The electric is a Sprague-Lundell pattern, $\frac{1}{4}$ HP. Both motors have a speed of 1,600 revolutions per minute.

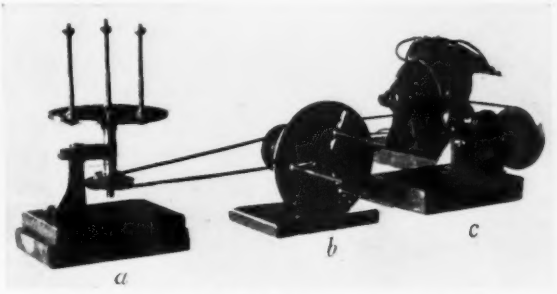

FIG. 2.—Two klinostats (*a* and *b*), the worm gear (*c*), and the electric motor back of the worm gear.

The worm gear (*fig. 3, a*).—As made by MILLER this reducing gear is manufactured in two sizes. In the smaller size the pulley worked by the worm has 100 teeth, thus reducing the speed to 0.01; in the larger size the pulley has 200 teeth, thus reducing to 0.005. Besides this reduction caused by the worm, the pulley attached to the worm shaft and receiving the belt from the motor is four times the diameter of the pulley of the motor shaft. Thus the total reduction by the worm gear brings the 1,600 revolutions of the motor down to four times or two times per minute, according to the use of the pulley with the 100 teeth or 200 teeth. A revolution of four times per minute has been shown by CZAPEK[4] to bring in centrifugal action unless the plant is kept within 5^{cm} of the axis of revolution; and hence, for merely neutralizing the effect of gravitation, one should still further

4 CZAPEK, Untersuchungen über Geotropismus. Jahrb. Wiss. Bot. **27**: 243. 1895.

reduce the speed from the smaller worm gear by interposing one of the step pulleys between the worm gear and the first klinostat. By the interposition of one such pulley, the speed of the first klinostat can be reduced to one revolution per minute, which is slow enough for objects less than one meter from the center of revolution. If desired, speed may be still farther reduced by other pulleys between the worm gear and the klinostat.

The shafts (*fig. 3, d*).—The shafts are of half-inch cold rolled steel, and are cut to any length.

The shaft supports (*fig. 3, c*).—These supports have a total minimum height of 12.5^{cm}, and by raising the upper part of the support may be extended to a height of 15.5^{cm}. This adjustment of the height of the support allows the shaft to be leveled up when the table or other object to which the supports are fastened is not level. The lower part of the support is a socket in which the stem of the upper part is held by a set-screw. The brass collar at the upper end of the support acts as a bearing, as shown in *fig. 1*, and automatically tilts up and down to conform to the direction of the shaft which passes through it. The middle piece of the support (*fig. 3, c*) has the shape of a tuning-fork, the stem of which is held in the socket below, and between the forks of which is received a plate projecting from the lower side of the collar above. An iron pin passing through the arms of the fork and the plate of the collar suspends and hinges the collar, and thus allows the automatic tilting. The three movements allowed the upper part of the support—that of vertical movement in the socket, rotation in the socket, and tilting of the collar—give ready adjustment to all possible faults of mounting of the shafts, prevent all binding, and have much to do with the easy running of the machines.

The pulleys (*fig. 3, d*).—The pulleys for the horizontal shafts are of cast iron, and made with three steps of 4, 8.5, and 15^{cm} diameter respectively. Each step has a peripheral thickness of 1^{cm} and has turned in it a V-shaped groove to take a quarter-inch leather belt. The pulleys are fastened to the shafts by set-screws.

Special turn-tables (*fig. 2, a* and *b; fig. 3, b*).—The foregoing apparatus is sufficient for centrifuges and klinostats revolving with horizontal axis. For revolution about a vertical axis the machines shown in the figures referred to have been made. They have an iron

base $20 \times 14 \times 2.5^{cm}$. An iron support screwed to this base rises vertically and carries at its upper end a horizontal arm which holds a collar through which passes the half-inch shaft of the machine. One end of this shaft, as shown in the figures, receives a brass two-step pulley, and the other end the usual plate for supporting the object under experiment. This plate is of heavy brass $15–20^{cm}$ in diameter, and has cut in it three equidistant radial slots which receive the ends of brass posts. The brass posts have shoulders which rest upon the brass plate on the upper side (*fig. 2, a*), while nuts on the opposite side secure the posts at any desired distance from

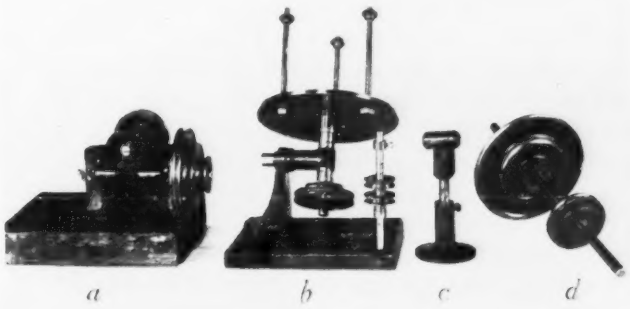

FIG. 3.—Worm gear (*a*), turn-table (*b*), shaft standard (*c*), and shaft and pulleys (*d*).

the center. The free ends of the posts have a thread on which runs a nut to be screwed down over the edge of a flower-pot or other container.

The horizontal arm projecting from the support rising from the base is held against the vertical support by a heavy friction screw passing through the vertical support and into the horizontal arm. This friction screw is turned by a removable steel rod passing through the head of the screw. By manipulating the friction screw, this machine may be set with its shaft at any angle desired, allowing the same klinostat to be used for revolution about a vertical, horizontal, or oblique axis (*fig. 2, a* and *b*).

Idler pulleys and support.—For adjusting the klinostats to cramped positions, or to fixed directions of light, it is often desired to turn a driving-belt from a straight course. This has been accomplished by means of the shaft and two small pulleys shown standing in the right-hand end of the klinostat base in *fig.* 3, *b*. This position of these idlers is right for the klinostat to which they are shown attached when the klinostat is adjusted for revolution with horizontal axis. For other purposes I have had made a cheap iron base into which the pulley shaft is set, and this device allows a belt to be turned at right or oblique angles anywhere desired.

Belting and couplings.—The belts used are of one-fourth inch leather. The thimble-like couplings screw over the ends of the belt and hook into one another. Both belting and couplings are common articles of trade.

Shaft-stops.—It is often desirable to keep a shaft from working out of some position in which it is placed or to prevent it being accidentally pushed out of position and thus destroying the alignment of the pulleys. For this purpose several collars are cut from half-inch brass tubing, and each collar is provided with a set-screw. Two such collars are shown one above and one below the small pulleys on the vertical shaft rising from the base of the klinostat (*fig.* 3, *b*).

Besides what has been already mentioned there are several things which might be added in commendation of this apparatus. It is easily portable, in spite of its seeming size. The parts may all be screwed to a movable table, or each part may be screwed to a piece of plank and the parts then clamped to tables. The shaft supports and bearings are easily shifted, placed nearer together or farther apart, so that one may use many shafts of various lengths with any two supports. One end of a horizontal shaft may be made to project any desired distance beyond a support, and the free end of the shaft may support a klinostat or centrifuge plate, thus allowing the plants used to be pushed into the recess of a window or into a small, closed chamber. The pulleys can be shifted to any position on the shafts, or any number of pulleys attached to a single shaft, thus allowing the turn-table driven by that shaft a variety of positions, or allowing several turn-tables to be driven from one shaft. The speed of revolution can anywhere be increased or diminished, and a variety of

speeds can be otained from the same shaft at the same time by belting to larger or smaller steps on the pulleys.

A machine, however simple and however powerful, is of little use unless it will accomplish the purpose of its design. A klinostat, as is well known, must move through any quadrant in the same time it traverses its counter-quadrant. The experience of years has demonstrated that the apparatus here described is not faulty in this particular. Of course, the loads must be balanced, and this is done as on any klinostat. There is no danger from the creeping or stretching of the belts. The unevenness of motion imparted by a water-motor attached to a central system seems to have no effect in causing either heliotropic or geotropic curves on the klinostats, the irregularities of one minute apparently correcting those of another, since the irregularities are not periodic.

Cost.—The minimum cost for a complete unit of this apparatus may be given thus:

1 ¼HP electric motor with rheostat		$35.00
1 ¼HP water motor	$24.00	
1 worm gear	12.50	12.50
2 shaft supports	2.50	2.50
2 ft. ½ in. steel shaft	.12	.12
1 3-step pulley	1.50	1.50
1 klinostat (*fig.* 2, *a* and *b*) revolving on either vertical or horizontal shaft	9.00	9.00
Total cost	$49.62	or $60.62

The equipment contained in this list provides a centrifuge with horizontal axis, revolving 800, 400, 200, 100 times per minute, and almost any lower speed, and with a klinostat revolving on either a vertical or horizontal axis with speeds from the centrifuge rate down to one revolution in four minutes. Moreover, it allows one centrifuge and one klinostat to be operated at the same time, or two centrifuges to be operated at the same time.

Additional centrifuges or klinostats with horizontal axis can be obtained tor $6 each, and with vertical axis for $9 each.

When one considers that the standard spring klinostats with but one turn-table cost $60 to $80, it can be seen that for the same expen-

diture the apparatus described in this paper possesses many times the efficiency of those, not counting cost of power.

Should anyone desire to construct this apparatus, I shall be willing to give additional details; or I will gratuitously supervise the construction should any one wish to have the work done by Mr. Miller. In the latter case, application for construction should be made to Messrs. Eberbach & Son, Ann Arbor, Mich., into whose employ Mr. Miller has entered.

UNIVERSITY OF MICHIGAN,
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ECOLOGICAL NOTES ON THE TREES OF THE BOTANICAL GARDEN AT NAPLES.

GRACE E. COOLEY.

(WITH FOUR FIGURES)

A VIEW of the country about the bay of Naples in the spring gives very little idea of the luxuriance of the vegetation of which the land is capable. The only trees left standing are the stone pines, and these are pruned to the very crown for firewood, leaving only the upper cone-bearing branches, which produce the seed the people so much enjoy. The ilex oaks never get much higher than the rosemary and the heather, and all are lopped for fagots, unless they have selected inaccessible rock niches to grow in. To be sure, the peasants cultivate the black poplars, but only for use in their vineyards. The living trees make the vine posts, and the cut branches of their pollarded trunks are used for stakes and cross-bars for the clinging tendrils. Every winter the shoots are cut back from the top of the trunk, and every summer a small new crop grows from the mutilated top, making a light shade from the hot rays of the sun.

It is a singularly treeless region. The impression of the country in the clear atmosphere is much like that of the foothills east of the Cascades in the rainless regions of Washington and Oregon. There is the same soft gray color on the hills, that readily changes under the influence of the sun and the clouds, and the gray artemisias on the rocks help to make the picture the same. Yet this land, so like our own desert in color and absence of trees, is very different in its power to produce the fruits of the soil. There is water to be had from the clouds in abundance at all seasons, except in the three summer months, and the apparent barrenness is only the result of the kind of crops the peasant plants, and the way he has dealt with the native trees. Every available spot is devoted to the cultivation of the grape, and the land is terraced for vines up the slopes of the old volcanic cones and sometimes down to the very depths of their worn-

out craters. All the wild shrubs go into the fire to cook the daily meal. The succulent cactus and the spiny century plant, fugitives from America, are protected from the hacking of the peasant's knife, and having escaped have made themselves perfectly at home here.

It is only in the gardens that one sees trees, and there one is struck by the cosmopolitan mixture. There are few natives of Italy, but many foreigners. The ilex oak is the hardiest of the natives, and the tree most often used along the avenues in the parks, but, with this exception and the cypresses and Judas trees, the gardeners have gone to other countries to get trees for adornment. A critical eye is at once struck by the multitude of plant types represented, and the marvel grows when one considers the exact habitat of the foreigners and the perfection of their development under cultivation here in Italy. This Mediterranean region is the home of the *Hartlaubgehölze* of the warm temperate zone, with the ilex oak, European olive, and classic laurel among the best-known and most representative examples; but there are Australian trees here from within the tropics; trees from the cold northern forests of our own land; some from the deserts of Africa; and others from the mountains of Asia. They stand for types of all the ecological regions of SCHIMPER, except the Arctic and the ever rainy forests of the tropics. The soil and the climatic conditions seem remarkably congenial to these strangers, and they appear to grow as well as under the conditions native to them.

The Royal Botanical Garden of Naples is an admirable place for the study of diverse types of trees, for it furnishes many species and these are growing almost in a state of nature. The funds of the garden have been for many years too small to give them much care beyond that which locks the gates and gives them the chance to live. The whole yearly allowance for the support of the gardens, the greenhouses, the library, and all the force employed from the director to the gatekeeper is 7000 lire (about $1400). Some years ago there was sometimes a little to be expected from the city of Naples, but the sum has been for many years too inadequate for what we should consider the actual needs of a botanical garden. One resident spoke of it as "a ruin twenty years ago," but the very ruin is of deepest interest to a student of ecology. It shows forms from many climates mingling

and growing freely under conditions unnatural to them at home, and the marvel is that they find it so easy to do it.

It is instructive to run over the climatic conditions that exist here and contrast them with what can be gathered concerning those of other lands which have representatives here. Naples lies in the warm temperature region of winter rains. The latitude is 40° 52′, the longitude 14° 15′ east. The garden is a short distance from the sea, from 31.30 to 44.50^{m} above it, and lies on a slope that looks southeast to Vesuvius. Back of it and protecting it from the north winds, rises the hill of Capodimonte, on which is an observatory from which the meteorological observations were taken which are given in the table below. Since the hill is much higher than the garden and more exposed, the conditions are not quite those which hold in the garden itself, 103^{m} below. In an account of the garden published in 1867 by PASQUALE, a former director, some of the climatic conditions are discussed. In 1846 there was a summary made of the observations of temperature for twenty-four years. The medium temperature for these years was 15.66° C. The highest temperature recorded was for July 17, 1841, 39° C.: the lowest was February 21, 1845, −5.8° C. The period of greatest heat succeeds July 25, and that of greatest cold January 24. Specially cold nights are recorded, when the temperature sank to −7° C. and −8° C. Such periods of extreme cold are rare, occurring perhaps only once in ten years. The thermometer seldom sinks to the freezing-point, and hoar frosts are most unusual. The table given below is for the year 1902, and is taken from the monthly reports published by the observatory of Capodimonte, 149^{m} above sea-level.

The rain falls for the most part in the winter, but the amount that falls in special months varies from year to year. In general it is greatest from October to February, and least in June, July, and August; in 1902 sinking to zero in July.

SCHIMPER divides the globe into regions according to the relative amounts of rain during the year and the seasons in which it falls. If we follow this classification in arranging the plants of the garden, grouping them with the countries where they are native, we shall be able to make some interesting comparisons.

METEOROLOGICAL OBSERVATIONS TAKEN AT CAPODIMONTE FOR THE YEAR 1902

Months	Average of maximum daily temperature C.	Average of minimum daily temperature C.	Average of relative humidity at 3 P. M.	Total rainfall in mm.	Evaporation in the 24 hours in mm.	Maximum temperature C.	Minimum temperature C.
January	11.88	7.23	62.8	65.6	44.8	....	0.8
February	13.32	8.66	76.6	103.4	34.1	16.0	4.1
March	14.12	8.19	68.7	76.1	50.9	17.5	2.4
April	18.79	12.26	71.6	65.8	55.6	21.7	6.5
May	18.35	11.42	55.3	80.2	70.3	26.3	8.0
June	23.90	16.59	55.0	8.0	107.0	29.7	11.0
July	28.73	20.50	61.1	0.0	137.7	31.3	17.8
August	28.66	20.29	62.7	9.0	110.5	33.6	16.0
September	26.14	18.98	64.3	82.5	102.1	32	13.6
October	20.34	15.41	78.7	171.7	59.8	26.3	10.2
November	14.98	9.80	70.8	157.8	47.0	18.5	5.3
December	11.23	6.91	67.8	66.9	46.3	....	2.1
				887.0			

1. *The temperate regions of winter rains and summer drouths.*—The countries included are Italy and the other lands bordering on the Mediterranean, the coast of southern California, and the coast region of southwestern Australia. These regions are in about the same latitude, and they all have an annual rainfall of 60–130^{cm}. Representatives in the garden are many, the ones selected for our purpose being as follows: ITALY: Quercus Ilex, Olea europaea, Laurus nobilis, Pinus Pinea, Cupressus sempervirens; GREECE to PERSIA and AFGHANISTAN: Pinus brutia; ASIA MINOR: Cedrus Libani; SOUTHWESTERN AUSTRALIA: Eucalyptus and Acacia; PACIFIC COAST OF SOUTHERN CALIFORNIA: Libocedrus decurrens, Chamaecyparis Lawsoniana, Cupressus macrocarpa, Pinus sabiniana, Sequoia sempervirens.

2. *The regions of heaviest rain in spring and early summer and the beginning of winter, with drouths in late summer.*—Included in this group are the greater parts of Spain, France, Switzerland, and Austria. The annual rainfall varies in these countries from 60 to over 130^{cm}. It will suffice to give only one or two examples from the many that could be given: Larix europaea, Fagus sylvatica, Quercus Suber, Pinus pyrenaica, Abies Pinsapo.

3. *The regions where all the months of the year are rainy or snowy.*—Included in this class are northern Europe, parts of Siberia and the

extreme north of Japan, North America on the east from Hudson Bay throughout the Alleghanies and on the west as far south as British Columbia. The range of latitude is from 30° northward; and the annual rainfall is 60–200^{cm}. EUROPE: Picea excelsa, Pinus sylvestris; SIBERIA, AMOOR REGION, and NORTHERN JAPAN: Abies firma, Cryptomeria japonica; WEST COAST OF AMERICA: Chamaecyparis nutkaensis; ALLEGHANY REGION: Pinus Strobus, Liriodendron tulipifera, Prunus serotina, Robinia pseudacacia, Celtis occidentalis, Tilia heterophylla, Gleditschia triacantha, Quercus nigra.

4. *The regions of winter rain or snow and heavy summer rains.*—Countries included in this group are British Columbia, Central Japan, and parts of Chile. The range of latitude is 40°–50°, and the annual rainfall is 130 to over 200^{cm}. Examples of these regions are as follows: BRITISH COLUMBIA: Chamaecyparis nutkaensis; CHILE: Araucaria imbricata; CENTRAL JAPAN: Chamaecyparis pisifera, Torreya nucifera.

5. *All the months of the year rainy, the most in winter, but no month without fifteen rainy days.*—The southern part of New Zealand is the only region where this condition holds. No trees of the garden are surely from this region, unless possibly a Dacrydium sp.

6. *All the months of the year rainless, at least with less than six days of rain.*—Under this group come the deserts of the Sahara, central Asia, central Australia, Arizona, and southern California. The latitude range is 20°–50°. This region is that of least rain, never more than 60^{cm} falling annually. OASES OF THE SAHARA: Phoenix dactylifera; GOBI: Tamarix articulata; ARIZONA: tree yuccas and agaves.

7. *Regions of the normal rainy season of the tropics and subtropics, with some drouth in winter and spring.*—The countries included are China, Japan, India, the East Indies, New Guinea, eastern Australia, southern Florida, the Mexican plateau, the West Indies, Central America, Peru, Brazil, and Argentine Republic. This region includes the monsoon forests of India and Brazil, where the annual rainfall exceeds 200^{cm}, the latitude ranging from the equator to 40°. The trees selected from the garden to represent this region are as follows: CHINA: Camphora officinalis, Ginkgo biloba, Cephalotaxus Fortunei, Chamaerops excelsa, Livistona chinensis; JAPAN:

magnolias and camellias; INDIA: Pinus excelsa (found also in an isolated area on a height in Greece), Acer oblongum, Corypha australis; NEW GUINEA, AUSTRALIA, and NEW ZEALAND: Araucaria Bidwellii, A. Cunninghamii, Melaleuca styphelioides, Calistemon saligneum alba, Grevillea robusta; SANDWICH ISLANDS: Pritchardia pacifica; BRAZIL and the ARGENTINE: Eugenia Michelii, Araucaria brasiliensis, Prosopis torquata; ANDES, PERU, BOLIVIA: Schinus molle, Phytolacca dioica; MEXICO: Pinus Montezumae, P. patula, Taxodium mucronatum, yuccas and agaves in regions of less rain; WEST INDIES: Cordia martinicensis; FLORIDA and the ADJACENT GULF STATES: Sabal Adansoni, Magnolia grandiflora, Planera aquatica, Liquidambar styraciflua, Torreya taxifolia, Persea Borbonia.

The plants chosen from the large number in the garden to represent the above regions have been selected particularly because they are well known as types of peculiarly significant societies. Another consideration, which is also a limitation, has restricted the examples to certain groups, such as the conifers and palms, because it has been impossible in many other cases to secure data as to the exact climatic conditions under which the trees are found in a natural state. Information of an exact nature in reference to this is most meager, as everyone knows who has consulted floras to find the ranges of species or the habits of plants with regard to environment. No plants were placed in the list which do not seem to be reasonably vigorous, and many of them are growing most vigorously, as will be seen by the following measurements of circumference taken 30^{cm} from the ground: *Pinus excelsa* 297^{cm}, *Camphora officinalis* 278^{cm} (spread of horizontal branches 12^{m}), *Taxodium mucronatum* 258^{cm}, *Sequoia sempervirens* 239^{cm}, *Cedrus Libani* 227^{cm}, *Araucaria Bidwellii* 195^{cm}, *Ginkgo biloba* 191^{cm}, *Chamaecyparis Lawsoniana* 172^{cm}.

The classification shows that the garden represents plants from 61° north latitude to 48° south latitude. Countries are represented with an annual rainfall of 20 to more than 220^{cm}. There are plants from the high mountains, the Canary pine growing at 2000^{m}; *Pinus excelsa* has a range on the Himalayas of 1800 to 3200^{m}; *Taxodium mucronatum* grows on the highlands of Mexico from 1600 to 2300^{m}; and *Pinus Montezumae* from 2500 to 4400^{m} on Orizaba. There are

plants that thrive in swamps and those that grow in rocky or sandy places. Few regions of the whole earth have not here their representatives.

Still more impressive than these plain facts is a walk in the garden itself in early spring, when the great variety of foliage shows itself to perfection. There is a yellow-green just appearing in the deciduous oaks and maples in the midst of the jungle of tropical evergreen trees with their glossy dark green foliage, and in sharp contrast to both are the gray phyllodial leaves of the Australian wattles, and such plants as *Colletia cruciata*, or the thin gray foliage of the lofty melaleucas and eucalyptus trees. Tree yuccas and tall dracaenas thrust their swordlike leaves through the soft sprays of the conifers. The date palms grow here vigorously and sometimes show a curious adornment of climbing ivies, while northern ferns and blossoming herbs grow in the axils of their fallen leaves. One such palm on close observation showed a score of young seedling maples that had taken root on the trunk of the tree, and had already passed their first summer successfully. Beside the maples, there were on the same tree trunk raspberries, grasses, geraniums, *Cotyledon umbilicus*, fumitory, masterwort, and perennial ferns, forming a most friendly and thriving community.

On superficial view of the trees there seems little variation from normal habit, but there is one tendency so strongly developed here that it seems to be climatic. Many trees develop root-shoots and sprouts from the old wood of the trunks. This is conspicuous in the conifers and palms, where it is certainly an exception to the usual habit of the groups. *Chamaecyparis Lawsoniana* has, besides the main trunk, four prominent ones given off just at the ground line, and they are conspicuously large and well-developed, the main trunk being 172^{cm} in circumference, and the others 56, 45, 40, and 40^{cm}.

Araucaria Cunninghamia has four bushy shoots about 90^{cm} from the base of the trunk. Some specimens of *Pinus canariensis* are clothed to the ground with filmy shoots, recalling the habit of many American elms (*fig. 1*). No other pine with which I am familiar has this habit except *P. rigida*, which frequently exhibits it in regions subject to forest fires.

One specimen of *Cryptomeria japonica* has a remarkable habit

of producing branches some distance from the ground which bend down, and when they meet the soil broaden out and root, throwing up erect stems which become independent trees. The tree is 110^{cm} in circumference and has given rise to six such independent growths, one 65^{cm} in circumference; the others 45, 30, 27.5, 12.5, and

FIG. 1.—*Pinus canariensis:* trunk clothed to the ground with shoots.

FIG. 2.—*Cryptomeria japonica*, showing one of five daughter trees from suckers; two suckers in view.

12.5^{cm}, all 30^{cm} from the ground. The highest of such rooting branches is given off from the trunk 60^{cm} above its base. It is 8.75^{cm} in circumference until it touches the ground, where it flattens and broadens to 15^{cm} in surface view, and creeps some distance from the trunk before rising into the erect shoot. *Fig. 2* shows only one of the daughter trees and two of the suckers.

Several specimens of *Phoenix dactylifera* in the garden produce

leafy shoots in the axils of the old leaves near the base of the trunk, and even some distance from the ground. A very remarkable case of this kind is shown in *fig. 3*, a photograph of a palm growing in a private garden in Naples. Twenty leafy shoots were counted on one side of the trunk alone. The trunk just above the soil measures

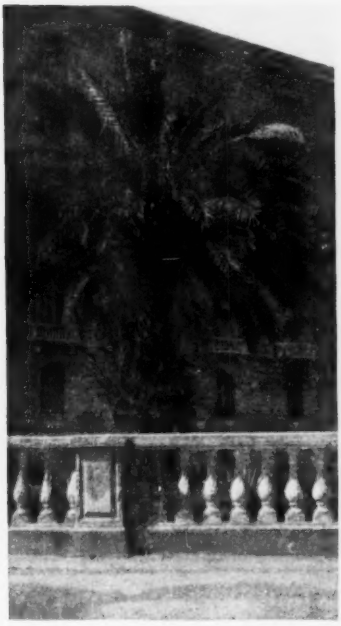

FIG. 3.—*Phoenix dactylifera*, with leafy shoots in the axils of old leaves.

FIG. 4.—*Phoenix dactylifera;* companion tree to that shown in *fig. 3*, whose leaves show in the upper foreground.

257^{cm} in circumference, but these abnormal growths so increase its size at a height of 130^{cm} that it measures 500^{cm}. In this tree and on the others in the botanical garden roots had arisen from the base of these shoots, but after growing a few centimeters they had died. *Fig. 4* shows the companion tree to the date palm of *fig. 3*, which has followed its natural habit. The branching one has not attained the height of the other, but is well developed in every other way.

Chamaerops humilis, the low native palm of the Mediterranean coasts, grows here into a thick bushy tangle from the development of an immense number of underground shoots. This is not an uncommon habit of the plant when growing wild in northern Africa. *Phytolacca dioica* has a curious flat table-like formation of its main roots or of the lower stem just above the ground line, and from this spring a great number of slender vigorous shoots.

The trees of the garden are not of great age, for the garden itself in its present foundation is not very old. Although as early as 1662 there was here a pharmaceutical garden connected with one of the church hospitals, in its present state it was founded in 1809 under the auspices of the Bourbon rulers. Its first director was MICHELE TENORE, who held the position for fifty years. He was succeeded by GUGLIELMO CASPARRI (1861–1866) and GIUSEPPE ANTONIO PASQUALE (1866–1867). In 1893 FREDIRIGO DELPINO, formerly in Genoa and Bologna, became its director, and he still holds the position. TENORE in his long term of fifty years put in train the plans which have been largely followed since. The important large trees now in the garden are included in a catalogue published in 1867 by PASQUALE. In many cases he gives the heights of the tallest trees, and from his figures we can judge that the growth since that time has been strong and normal. With a few exceptions the trees are probably none of them much older than one hundred years. A few of them have been broken by tempests and one or two are stag-headed, but most of them show no signs of abnormal growth. They are not well pruned, but in a natural woodland condition that is most interesting.

It is a remarkable collection when one considers how little care has been given it. One marvels at the friendliness of the climate which has proved congenial to so many strangers. In our own country southern California has a somewhat similar type of native vegetation and somewhat similar climatic conditions, but even there it would hardly be safe to leave such a collection of trees to themselves. One feature of importance is the great fertility of the soil in this region, which has been under the influence of civilization for three thousand years, and probably a good part of that time under cultivation, yet it still yields several harvests a year.

Such a climate as this would be an ideal one in which to establish an experimental garden, with the study of variation in structure in special view. The garden already contains valuable material for research. Naples has proved to be a splendid situation for the Marine Biological Laboratory. There is a place here also for a great botanical station for the study of plants from all the world. The botanists have left the ecology of this region almost untouched until lately, and now Professor J. Y. BERGEN is working on the plants of the Solfatara. This pioneer work should indicate the possibilities of this region as a place where the American botanists might establish a station which would do for botany what the German zoologists have done for zoology.

STAZIONE ZOOLOGICA,
Naples.

RELATIVE TRANSPIRATION OF OLD AND NEW LEAVES OF THE MYRTUS TYPE.

JOSEPH Y. BERGEN.

WHILE making some studies of the transpiration of the coriaceous-leaved evergreens of the Neapolitan region, such as *Olea*, *Pistacia*, and *Quercus Ilex*, the writer became interested in the question of the relative activity in transpiration of their old and new leaves. Some results of the measurements made upon them are here set down, together with a few words of discussion in regard to the meaning of the facts observed.

It is commonly said that the trees and shrubs of the Mediterranean region are largely evergreen, but a little examination into their characteristics shows that the word "evergreen" should be used to describe them only when its meaning is carefully defined. When local floras, like GUSSONE'S excellent catalogue of the plants of Ischia, describe such summer deciduous shrubs as *Spartium junceum*, *Cytisus scoparius*, and *Calycotome villosa* as evergreens, it would seem that any woody plant with leaves which remain green during a considerable part of the winter is considered to be an evergreen. As a matter of fact, the angiospermous trees and shrubs of the coast-wise region about Naples seem to be classifiable, as regards their mode of shedding the leaves, into the divisions shown in the table[1] on the opposite page.

Some of the plants of division I may be described as facultative deciduous species; that is, they may retain their leaves almost or quite the year around. The Medicago and the Euphorbia above named do this when the water supply is abundant.

The members of division II are more or less covered with leaves at all seasons. Those which belong to subdivision 1 show little difference in density of foliage dependent on the season. Many, however, of subdivision 2 lose nearly all their old leaves soon after the new leaves have reached their full size (area). *Rhamnus Alater-*

[1] The table given is merely illustrative and does not embrace nearly all the species which the writer has observed.

I. Leaves simultaneously deciduous	1. Winter deciduous	*Juglans*, *Populus*, *Fagus*, *Castanea*, *Quercus* (in part), *Ulmus*, *Morus*, *Ficus*, *Vitis*, etc.
	2. Summer deciduous	*Calycotome villosa* *Coronilla Emerus* *Spartium junceum* *Medicago arborescens* *Euphorbia dendroides*
I. Leaves not simultaneously deciduous (evergreen)	1. Leave some of them lasting two years or more	*Olea europaea* *Pistacia Lentiscus*
	2. Leaves lasting more than one year but less than two	*Rhamnus Alaternus*[2] *Nerium Oleander*[2] *Quercus Ilex*[3] *Ceratonia Siliqua*[3] *Arbutus Unedo*[3]

nus and *Nerium Oleander* are therefore much less leafy by July 1 than they were throughout May.

A large proportion of the time spent was devoted to leaves of the so-called Myrtus type; those namely of *Olea europaea*, *Quercus Ilex*, *Rhamnus Alaternus*, and *Nerium Oleander*.

Four other species, namely, *Pistacia Lentiscus*, *Hedera Helix*, *Smilax aspera*, and *Viburnum Tinus*, were also studied, in order to give any conclusions that were reached a more general value, as applicable to the sclerophyll trees and shrubs of the region.

With every species, some comparisons of the relative rate of transpiration for old and new leaves were made as soon as the latter had reached their full areal growth.

RELATIVE THICKNESS OF OLD AND NEW LEAVES.

On comparing the thickness of the old leaves with that of new ones of the same species which had just reached their full area (usually in May) the older ones were commonly found to be somewhat thicker. All of the species in the list above given were examined except Viburnum, and the average ratio for all seven species was $\frac{\text{thickness old leaf}}{\text{thickness new leaf}} = 1.2$. The greatest disparity was found in Pistacia, which sometimes gave a ratio of 1.48, and the least was in Hedera, which frequently showed no difference in the respective thicknesses. The greater thickness of the old leaves was not mainly due to growth of the

[2] These last fifteen months or but little more. [3] These last eighteen months or more.

epidermis; the amount due to this cause was never found to be more than 10 per cent. of the whole difference in thickness, and sometimes the epidermis of the new leaf was as thick as that of the old one. All the measurements were carefully made with the eye-piece micrometer.

RELATIVE TRANSPIRATION OF OLD AND NEW LEAVES.

The measurements of transpiration were all made by determination of loss of weight of twigs in water, except in the case of Nerium of which leaves only were used, with the petioles immersed. The time allowed was usually one hour, and the temperature (always the same for each comparison) ranged on different days from 25 to 31° C. Observations were begun on May 8 and continued at intervals until August 6.

In the following table are given the ratios of rates of transpiration for equal areas of old leaves and new ones which had just attained their maximum area. The values given are usually averages of several observations taken daily or at intervals of two or three days during a period of a week or ten days. The column $o \div n$ represents the ratio, *amount of transpiration per hour for* $100^{sq\ cm}$ *of old leaves divided by the corresponding amount for new leaves.*

TRANSPIRATION RATIOS; EQUAL AREAS.

	$o \div n$
Olea europaea	1.05
Quercus Ilex	3.53
Rhamnus Alaternus	0.78
Nerium Oleander	2.45
Pistacia Lentiscus	1.08
Hedera Helix	0.18
Smilax aspera	2.16
Viburnum Tinus	2.10

It is obvious at a glance that in general the new leaves have not attained their full power of transpiration when they have reached the area of maturity. This fact is not wholly a result of the imperfect development in thickness already mentioned, for when the transpiration ratios are referred, not to equal areas of leaves, but to equal weights, the older leaves often maintain their position as the more active, as is sufficiently shown by the following values. These results cannot be closely compared with those of the preceding table, since

the former contains averages based on a larger number of determinations for each species.

TRANSPIRATION RATIOS; EQUAL WEIGHTS.

	$o \div n$
Quercus Ilex	2.73
Smilax aspera	2.32
Viburnum Tinus	1.74

In two species, the Rhamnus and the Hedera, the old leaves are seen to be notably deficient in capacity for transpiration. In the former this fact is very possibly due to the moribund condition of the old leaves, which at the time of observation were about to turn yellow and fall. In the latter, the leaves were not ready to fall, and some other explanation of their sluggish action needs to be sought.

In view of the marked differences in transpiration between the old and the new leaves of most of the species studied, it seemed worth while to investigate the question whether these differences were accentuated or diminished by covering the stomatal surface (the lower one) with wax and so comparing the normal transpiration with the epidermal taken alone. This inquiry was not undertaken until so late in the season that only a portion of the comparisons which it would have been desirable to make were possible. The most convenient way of expressing the results seemed to be to give the ratio, *loss of water by plain leaf divided by loss of water by waxed leaf*, first for the old leaves, then for the new ones, of each species examined.

TRANSPIRATION RATIOS; PLAIN AND WAXED LEAVES

	Plain ÷ Waxed	
	Old leaves	New leaves
Olea europaea	2.62	3.17
Nerium Oleander	3.52	12.75
Pistacia Lentiscus	3.00	5.33
Hedera Helix	2.93	6.80

In the species examined it is evident that the total transpiration exceeds the epidermal alone much more in the new leaves than the old ones. Examination of the actual amounts of moisture lost in each case leads me to suppose that this inequality is due to the

greater impermeability of young epidermis (several months old) than of that which is more than a year old, and to the greater functional activity of the younger than of the older stomata. One would *a priori* have expected to find the thicker and more indurated epidermis of the older leaves more impermeable than that of the younger ones, but in many cases it certainly is not. For instance, the older leaves of Nerium were found to lose moisture more than five times as fast for equal areas as the younger ones (both with the lower surface waxed), and the older leaves of Olea lost moisture nearly four times as fast as the younger ones (both waxed below).

In the table above given the losses from waxed leaves may be a little too high relatively to the losses from plain leaves, since the former values were obtained after the leaves had been standing in water longer, and therefore, perhaps may have established a better transpiration current. But this would not affect the general conclusions to be derived from the data.

The leaves of Olea and of Pistacia compared in the last table were aged about six months ("young") and eighteen months ("old") respectively, and those of Nerium and Hedera were about three and a half and fifteen and a half months of age.

None of the results obtained by the writer in transpiration experiments upon sclerophyll leaves can be much elucidated by comparison with the conclusions (contradictory among themselves) obtained in the studies of young and old leaves by SCHIRMER, KRUTITZKY, TSCHAPLOWITZ, HÖHNEL, and others,[4] since none of these authors dealt with leaves which differed in age by an entire year. It is also unlikely that sclerophyll leaves should in their behavior as regards transpiration closely resemble the leaves of the herbaceous Gramineae, those of Coleus, Phaseolus, Pisum, and such other species as have received most study with reference to the relation between their development and their power of transpiration.

CONCLUSIONS.

The conclusions of the present paper may be summarized as follows:

1. The evergreen trees and shrubs of the Neapolitan region differ greatly in the longevity of their leaves, some of the species having

[4] Summarized by BURGENSTEIN, Materialien zu einer Monographie betreffend die Erscheinungen der Transpiration der Pflanzen. II Theil, pp. 25, 26. Wien. 1889. A. Hölder.

leaves that live only about fifteen months, while those of others live more than two and a half years.

2. All of the leaves studied reach their maximum area considerably before they attain their full thickness.

3. The leaves of six out of the eight species studied transpire more for equal areas when fifteen to eighteen months old than they do when they have just reached their maximum area (*i. e.*, at three or four months).

4. Transpiration for equal weights of leaves is generally more active for leaves of fifteen or more months than for those of three months or a little older.

5. Epidermal transpiration bears a much smaller ratio to total transpiration in leaves of three months than in those of fifteen months.

NAPLES, ITALY.

REGENERATION IN ZAMIA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY LXV.

JOHN M. COULTER and M. A. CHRYSLER.

(WITH EIGHT FIGURES)

MR. P. H. ROLFS, in charge of the Subtropical Laboratory of the United States Department of Agriculture at Miami, Florida, first called our attention to the remarkable power exhibited by mutilated stems of *Zamia floridana* of producing new shoots and roots. This cycad grows in great abundance in the neighborhood of the station, and ROLFS stated that he had seen "portions (of the stem) not larger than an English walnut" produce both shoot and root. He was kind enough to send an abundant supply of this mutilated and sprouting material, collected about February 1, 1904. The plants grow at Miami in a pure and well-drained sand, with a soil temperature standing rather uniformly at about 30° C. On April 16 ROLFS reported that the temperature of the soil one inch below the surface was 40° C.; three inches below, 38° C.; and six inches below, 35° C.

In most of the cases studied, the top of the thick stem had been cut off by the grubbing hoe, leaving the subterranean portion intact, though all of the smaller roots were lacking. Some of these stems were planted and observed at intervals. One of them, a plant about two years old, was placed in the greenhouse about February 13; the fully spread leaves soon withered, and no activity was visible for two and a half months, at the end of which time a new leaf was put forth from the bud. On June 1 the plant was removed carefully from the soil, its appearance being shown in *fig. 2*. The stem had been cut off at *x*, and had produced a new apex. Since the last planting no ordinary roots had been produced, though an upwardly directed spur 2 mm long (not shown in the photograph) indicated the beginning of one of the characteristic apogeotropic roots; and yet the young shoot was in vigorous condition.

An attempt was made to discover experimentally the possible

anatomical limitations of this reproductive power, by artificial mutilations of various kinds, but probably the proper conditions for vigorous growth were not maintained; at least no results were obtained.

We have found no record of this behavior of Zamia, except in a statement made by WILLDENOW,[1] a century ago, of which the following is a translation:

> The majority of palms die as soon as their trunk is cut or even damaged. There are only a very small number of them which, like *Chamaerops humilis* and *Rhapis flabelliformis*, send out from their root new shoots; and *Cycas circinalis* is the only one which sends out shoots from its trunk when this has been cut; further, the stem of this tree gives out new roots where it finds itself in contact with the soil. The different species of Zamia may be cut up and thus multiplied artificially by cuttings, but with the exception of Cycas and Zamia no other palm survives amputation of the stem.

This power of producing new shoots and roots after mutilation is usually called "regeneration," but this term seems to have been applied primarily rather to the restoration of lost parts than to the production of a complete new structure. As a consequence of its broader application, there has been a tendency to regard the regeneration ordinarily observed in plants and in animals as of two distinct kinds; the former being nothing more than adventitious budding, the latter actual restoration of lost parts, the new structure becoming an integral part of the old. The great majority of the illustrations of regeneration in plants are cases of adventitious budding rather than regeneration in the stricter sense. We recognize the fact that the whole subject of regeneration among plants is in an inchoate condition, but perhaps the two kinds cannot be distinguished by any exact definition. Most of the cases presented in this paper are not regeneration in the restricted sense defined above, but in addition to adventitious sprouting in Zamia there also seem to be cases of direct restoration of lost parts.

In the mutilated (mostly decapitated) stems of Zamia studied, the new shoots arise most frequently from the vascular part of the central cylinder, as many as five shoots having been observed to spring from this region in a stem 3 ^{cm} in diameter, though only one shoot may occur. The vascular elements present in these shoots

[1] WILLDENOW, C. L., De quelques nouveaux palmiers de l'Amérique méridionale. Mém. Acad. Roy. Berlin, 1804, p. 29.

are continuous with the vascular tissue of the central cylinder of the parent stem.

Less frequently, the new shoots arise from the peripheral part of the wounded surface of the cortex. Both of these regions of origin may be used in the same stem, as illustrated by *fig. 1*. In the case just referred to, a distinct group of vascular strands was traced from each shoot to the vascular tissues of the central cylinder. In certain other cases no vascular connection was found, due probably to the fact that the shoots were younger and undifferentiated.

FIG. 1.—Decapitated stem showing one shoot growing from the vascular ring and one from the margin of the wounded surface. × $\frac{3}{8}$.

In a few cases the new structure stands directly over the central cylinder, as illustrated by *fig. 2* and observed also in much older plants. In such cases, a series of vertical sections shows that the vascular tissues of the central cylinder converge to form a dome-shaped cap underneath the restored part (*fig. 3*), that is, the whole cut end of the central cylinder regenerates, in the strict sense, the lost part being thus restored. In all other cases there is no such restoration, but the production of entirely distinct and complete structures upon the old stem. Just what conditions deter-

FIG. 2.—Young plant which was decapitated at *x* and has produced a new apex. × $\frac{7}{8}$.

mine the formation of a complete new structure in the one case, and the restoration of the lost part of the old structure in another case may not be clear, but it is entirely probable that the central cylinder is more apt to be restored in young plants.

The origin of the new roots is just as variable. It is customary to think of secondary roots as arising from vascular tissue, and this was found to be true in several of the cases studied. In the case illustrated by *fig. 4*, however, no trace of central cylinder was found, the piece of stem from which the shoot springs on one side and the root on the opposite side being simply a chip from the cortex of an old stem. Between this shoot and root of cortical origin a distinct and complete vascular connection was traced, the vascular elements forming a hollow cylinder tapering at the ends (*fig. 5*). It seems certain that the decay of the "chip" in this case would uncover a completely organized new plant. In any event, from this isolated cortex new organs and new kinds of tissue have been formed, the new shoot arising from the outer edge of the cortex in the region of the cork cambium, and the root arising from a more internal region of cortex. Whether the starting of the shoot determined the root, or *vice versa*, or neither, are matters of conjecture, but a completely organized and independent new plant has been derived from isolated and relatively old cortical tissue.

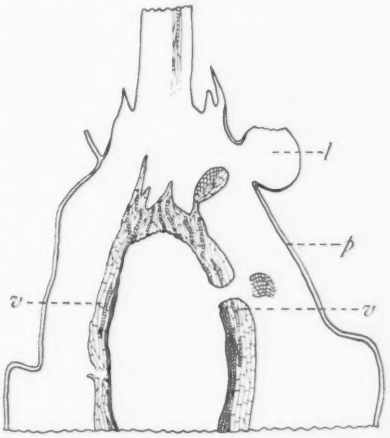

FIG. 3.—Median vertical section through apex of stem represented in *fig. 2*: *l*, base of leaf; *p*, periderm; *v*, vascular cylinder. × 4.

The attempt was made to determine the exact layer or tissue from which the new shoots proceed. It seems evident that regions of meristematic tissue alone are concerned, that is tissue which has either remained so or has resumed its power of cell-division; and in the ordinary cycadean stem there are at least three such active regions

in addition to the growing point, namely the fascicular cambium, the pericycle, and the cork cambium. SIMON[2] finds that in regenerating root-tips the pericycle is the active layer. In Zamia the pericycle is poorly differentiated, and does not act as a secondary cambium, as is the case in Cycas and certain other cycadean genera. In the cases observed the new shoots nearly always arise from the wounded surface; and as a layer of wound-phellogen is always found beneath this surface it must be added to the list of active regions. It has been impossible thus far to secure the earliest stages in this adventitious shoot-formation, but sections through moderately young regions of this kind show the layer of callus curving outward around the base of the shoot-primordium (*fig.* 7). This suggests that the phellogen forming the callus is responsible for the initial growth of the new shoot. If this be true, a new shoot may be produced at any point of the surface covered by the callus. In fact, in the cases of Zamia before us the new shoots stand over either fascicular cambium or cork cambium, but this position seems to us to be favorable rather than essential to shoot-formation.

FIG. 4.—A chip from the cortex that has produced a new shoot and root. × $\frac{3}{8}$.

A case of the production of adventitious shoots from the hypocotyl

[2] SIMON, S., Untersuchungen über die Regeneration der Wurzelspitze. Jahrb. Wiss. Bot. **40**: 103–143. 1904.

of a seedling was also observed (*fig. 6*). The photograph shows a leaf arising from a bud on one side of the hypocotyl; another bud, younger than the one shown, is present on the opposite side. Anatomical examination showed that the bud contains a strong vascular strand that runs straight inwards to join one of the bundles of the hypocotyl. A layer of periderm is present just beneath the surface of the hypocotyl, and around the bud this layer bends outward to form a sort of collar (*fig. 7*). The tissues of the bud show no evidence of breaking through the cortex, as is the case with lateral roots; hence it is probable that growth of the shoot started in the phellogen. Whether the bend of the hypocotyl indicates some slight injury or not cannot be answered, at least there is no direct evidence of an injury of any kind.

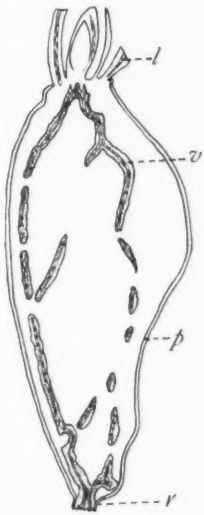

FIG. 5.—Vertical section through the piece shown in *fig. 4*: *l*, base of leaf; *p*, periderm; *r*, root; *v*, vascular cylinder. × 2.

That a so-called polarity does not determine in this case the nature of the structure produced at each end of the mutilated stem, seems to be indicated by such a case as that represented by *fig. 8*, in which two new shoots and a root are arising from one end and a shoot

FIG. 6.—Seedling showing production of shoot from the hypocotyl. × ¾.

from the other. It is probable that the horizontal position of the old stem is directly related to this result; and if so it would be referred to the influence of gravity.

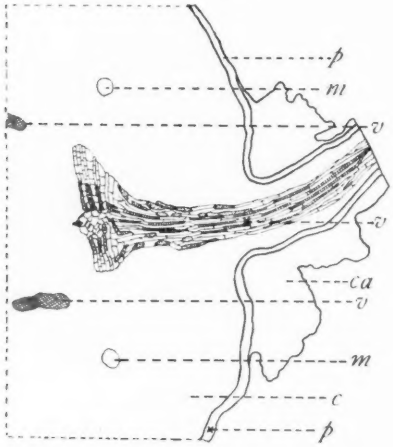

FIG. 7.—Part of transverse section through hypocotyl at level of the new shoot: *c*, cortex; *ca*, callus; *m*, mucilage duct; *p*, periderm; *v*, vascular strands. × 10.

The suggested conclusions are that in the case of the stem of Zamia the power of regeneration and of developing adventitious shoots and roots is present in all meristematic tissue; that in cases of mutilation the meristematic tissue chiefly concerned is the phellogen of the callus, that over the region of the central cylinder being more often successful than that over the cortex. This power does not seem to be localized in any definite points, such as have been called "latent buds," and which in this sense can have only a hypothetical existence; but is generally present in all meristem and expresses itself under favorable conditions. The evidence against wounding as a necessary condition for such production of new shoots is suggestive, and that against the theories of "polarity" and "latent buds" seems to be clear.

FIG. 8.—Piece of stem showing two shoots and a root springing from one end and a shoot from the other end. × $\frac{3}{5}$.

UNIVERSITY OF CHICAGO.

BRIEFER ARTICLES.

NEW OR UNREPORTED PLANTS FROM SOUTHERN CALIFORNIA.

SPARGANIUM GREENEI Morong, Bull. Torr. Bot. Club **15**:77. *pl. 79, fig. 3.*—Collected near Ballona, in marshes near the coast of Los Angeles co., July 1904, by *Geo. B. Grant.* The type was collected at Olema, Marin co., and the plant is common there and at Lake Merced, near San Francisco, but has not been met with heretofore elsewhere.

POA HANSENI Scribner, U. S. Dept. Agric., Div. Agrost., Bull. 15: p. 53. *pl. 9.*—In an alkaline meadow at Rabbit Springs, 2700^{ft} alt., Mojave Desert, 4888 *Parish*, June 1901. This and the following grasses were identified at the Division of Agrostology of the U. S. Department of Agriculture.

POA LONGILIGUA Scribner and Merritt, U. S. Dept. Agric., Div. Agrost., Circ. **9**:3.—In open pine forests, Mill Creek Falls, 5500^{ft} alt., San Bernardino Mts., 5043 *Parish*, June 1901.

POA SECUNDA Presl, Rel. Haenk. **1**:271.—Collected at the same time and place as the preceding species, and distributed under no. 5044.

ERAGROSTIS REPTANS Nees, Agrost. Parag. 514. *E. hypecoides* B. S. P. Prelim. Cat. N. Y. 69.—Los Angeles, *Rev. J. C. Nevin*, 1904. Probably a recent immigrant.

FESTUCA CALIFORNICA Vasey, Contrib. U. S. Nat. Herb. **1**:277.—Forest clad slopes, Mill Creek Mts., Head of Edgar Cañon, 4000^{ft} alt., May 1881, 857 *Parish;* Mill Creek Falls, 5000^{ft} alt., July 1892, 2490 *Parish.* The type of this species was collected near San Francisco, whence it extends to Oregon. The present report brings it nearly to the southern boundary of the state.

SITANION RIGIDUM J. G. Smith, U. S. Dept. Agric., Div. Agrost., Bull. 18:13.—Collected by *Mrs. H. E. Wilder*, June 1904, growing in the crevices of rocks on the summit of Grayback Mt., 11,725^{ft} alt. The nearest station reported for this grass is Mt. Shasta, at the northern end of the state, but it may be expected on the intervening high summits of the Sierra Nevada.

JUNCUS TENUIS CONGESTUS Engelm. Trans. St. Louis Acad. **7**:450, Prairie Flat, 5,000^{ft} alt., 3959 *Parish*, June 1895.

CHENOPODIUM LEPTOPHYLLUM Nutt., Moq. in DC. Prodr. **13**^{2}:71.—I have a specimen of this plant collected long ago at Lang, Los Angeles co., by *Rev. J. C. Nevin*. Subsequent collectors appear to have overlooked it.

SAXIFRAGA PUNCTATA Linn. Sp. Pl. 401.—Dry Lake, Grayback Mt., about 9000^{ft} alt., June 1904, *Mrs. H. E. Wilder*. Mt. Whitney, where it was collected by Coville, is the nearest recorded station, so that the present one becomes the southern limit of this species in the Sierra Nevada.

SPIRAEA DOUGLASII Hook. Fl. Bor.-Am. **1**:172.—Near the electric power-house in the cañon of the Santa Ana River, San Bernardino Mts. Collected in 1903 by *Miss Marguerite Graham*. The southern limit of the species.

Horkelia Wilderae, n. sp.—The whole plant sparsely pubescent: stems several from a perpendicular root, 2^{dm} tall, slender, erect, much branched above: stipules lanceolate, entire or 1- or 2-toothed at base; basal leaves 6–8^{cm} long; leaflets 5 or 6 pairs, cuneate, 5^{mm} long, deeply incised, the few lobes oblong; upper cauline leaves unifoliate, deeply dissected: cyme diffuse: flowers numerous on slender pedicels, 3–8^{mm} long: hypanthium glabrate, saucer-shaped, about 2^{mm} in diameter; bracts linear-oblong, obtuse or acutish, 1^{mm} long: calyx lobes lanceolate, 2^{mm} long: petals obovate, white, about equaling the sepals: stamens 10: achenes 2 or 3.—Along the trail leading from Barton Flat to South Fork of Santa Ana River, 6000–8000^{ft} alt., San Bernardino Mts., June 1904, *Mrs. H. E. Wilder*. The stems, and still more the calyces, are tinged reddish-purple, so that the whole plant appears of that color. Even the leaves soon become highly colored. Near *H. Michneri* Rydb., from which species it is well distinguished by its more diffuse cyme, smaller pedicellate flowers, and glabrous calyx lobes.

Drymocallis viscida, n. sp.—Viscidly villous throughout, with intermingled straight one-celled and crisped glandular several-celled hairs, which are sparse on the stems and abundant on the peduncles: stems several, erect, tinged with purple, about 3^{dm} tall: stipules semiovate and acuminate-pointed, more or less toothed; basal leaves tufted, about 1^{dm} long; petioles as long as the rachis of the pinnae, of which there are 3 pairs, 5–15^{cm} long, orbicular to obovate, the terminal one cuneate, sessile; the lowest cauline leaves similar, the upper ternate to unifoliate, all coarsely incised-toothed: cymes rather condensed, few-flowered: bractlets narrowly lanceolate, 2^{mm} long: sepals ovate-lanceolate, callous-tipped, 5^{mm} long: petals yellow, obovate, a little shorter than the sepals, both merely spreading in anthesis; stamens about 20; filaments 1 to 1.5^{mm} in the same flower.—

Snow Cañon, 5000ft alt., San Bernardino Mts., 5060 *Parish*, June 20, 1901. Near *D. reflexa* Rydb., from which it differs in its smaller size, pubescence, and spreading sepals and petals.

TRIFOLIUM MONANTHUM TENERUM. *T. monanthum* Eastw. Bull. Torr. Bot. Club **29**:81.—In meadows, at high altitudes in the San Bernardino Mts., Bluff Lake, 7400ft alt., 3309 *Parish*, June 1894; Vivian Cañon, 6343 *Geo. B. Grant*, July 1904.

HOSACKIA TORREYI Gray, Proc. Amer. Acad. **8**:625.—Little Bear Valley, 5500ft alt., San Bernardino Mts., *Mrs. H. E. Wilder*, September 1904.

PELARGONIUM AUSTRALE CLANDESTINUM Hook. Fl. N. Zea. 37. *P. clandestinum* L' Her. ex DC. Prodr. **1**:660, as synonym.—Santa Ana, Orange co., *Rev. J. C. Nevin*, 1904. Perhaps only adventive, or casual, but of interest as the second species of this genus collected in North America. The previously reported species is also from California, having been collected near San Francisco by Miss Eastwood. Identified by Dr. GREENMAN.

RHUS GLABRA Linn. Sp. Pl. 265.—Chino Cañon, near Palm Springs, at the desert base of San Jacinto Mt., November 1903, *H. E. Hasse*. Dr. Hasse's interesting find adds the first true sumac to the state flora, the previously known species belonging to other sections of the genus. This station becomes the western limit of the species.

Gentiana viridula, n. sp.—Annual: stem leafy, erect, simple, or few branched, 3–6cm tall: leaves narrowly scarious-margined, the lowest orbicular, apiculate, 5mm in diameter; the upper narrowly oblong, 5mm long, obtuse, connate-sheathing: flowers solitary, terminal: corolla funnelform, 5mm long; the lobes greenish, acute; the plaits at the sinuses blue, one-toothed: anthers oblong; filaments 1mm long: capsule (immature) obovate, on a stout stipe 3mm long.—Growing at the edge of water at the head of the South Fork of the Santa Ana River, 8500ft alt., San Bernardino Mts., *Mrs. H. E. Wilder*, June 1904. §CHONDROPHYLLA Bunge, and near *G. prostrata* Haenke.

MENTHA CITRATA Ehrh. Beitr. **7**:150.—Well established along Town Creek, near San Bernardino, September 1904. In the *Manual of the Bay Region*, Greene reports this mint from West Berkeley. Apparently it is rather rare in the older states.

Aster defoliatus, n. sp.—About 1m tall, minutely hispid above: stem leaves unknown, early deciduous; those of the pedicels narrow and bract-like, pungent, 3–8cm long: heads in a loose elongated raceme, solitary or rarely 2 or 3 at the ends of the elongated leafy pedicels, small, 8cm high and somewhat broader; bracts narrow, the green tips not much enlarged, loosely imbricated in a few series: rays about 40, light violet: achenes

hispid.—In a meadow at San Bernardino, 5335 *Parish*, October 17, 1903. This species belongs to Gray's subsection DIVERGENTES, and is quite distinct from any other Aster of Southern California.

ANTENNARIA MARGINATA Greene, Pitt. **3**:290.—Grayback Mt., about 7000^{ft} alt., June 1904, *Mrs. H. E. Wilder*. A New Mexican species. Identified by DR. GREENE.

PSILOCARPUS TENELLUS Nutt. Trans. Am. Phil. Soc. **7**:340.—In the coastal subregion, probably not uncommon. San Diego, *Brandegee;* Glendale, near Los Angeles, *Braunton*.

Senecio sparsilobatus, n. sp.—A cespitose perennial, tomentose throughout: stems few, slender, 10–15^{cm} tall: basal leaves 5–7^{cm} long, the long petioles bearing near the end about five cuneate toothed pinnae 3–5^{cm} long; those of the stem similar, but few and reduced: heads 1^{cm} high, calyculate with 2 or 3 short filiform bracts, these glabrate on the margins; rays 8, disk flowers numerous.—Collected June 1904 by *Mrs. H. E. Wilder*, at about 7000^{ft} alt., on the trail from Barton Flats to South Fork of Santa Ana River, in the San Bernardino Mts.

CENTAUREA CYANUS Linn. Sp. Pl. 911.—Well established at the race track, Los Angeles, where it was collected in the present year by the *Rev. J. C. Nevin*.—S. B. PARISH, *San Bernardino, California*.

CURRENT LITERATURE.

BOOK REVIEWS.

The phenomena of fertilization.

FECUNDATION in plants is the subject of a treatise by MOTTIER[1] published by the Carnegie Institution, in which is discussed a variety of cytological topics. In judging the work the reader should bear in mind that the preface is dated August 1902, more than two years previous to the time of actual publication, a delay on the part of the Carnegie Institution that seems somewhat unjust to the author, and unfortunate in that it has withheld from investigators for many months an important contribution in a field of very active research where points of view change rapidly by reason of new discoveries. The book is chiefly a discussion of the nuclear activities connected with "fecundation," as the author prefers to call the fusion of sexual cells instead of using the more usual term fertilization.

Preliminary to the main discussion MOTTIER gives a general account of nuclear and cell division, based chiefly on his own work upon Dictyota and various types of the Liliaceae. There is a brief account of the centrosome and blepharoplast, the author believing that the latter structure arises *de novo* and holds no genetic relation to the former, which is the opinion of STRASBURGER, WEBBER, and others. The topic "significance of the sexual process and the numerical reduction of the chromosomes" is an excellent summary of STRASBURGER'S views on antithetic alternation of generations.

The last two-thirds of the work treats of sexual processes as understood in the plant kingdom, beginning with Ulothrix and Hydrodictyon and continuing through higher groups, without any attempt, however, at an evolutionary discussion. Indeed, the arrangement of forms follows closely the old classification of Sachs into zygosporic, oosporic, and carposporic types of sexual reproduction. Thus the arrangement of types of the Conjugales side by side with Sporodinia under the heading "non-motile isogametes" seems a very artificial division, in view of the many recent studies on multinucleate gametes (coenogametes). It is among the thallophytes that the work is likely to suffer most from the advancing investigations, and since 1902 papers on the coenogametes of several ascomycetes have appeared, also accounts of oogenesis in Vaucheria and Saprolegnia, while the recent work of WOLFE on Nemalion is likely to change very materially our conception of the morphology of the sexual organs in the Rhodophyceae.

The account of the archegoniates and angiosperms describes in detail the

[1] MOTTIER, D. M., Fecundation in plants. imp. 8vo. pp. viii + 187. *figs.* 75. Washington, D. C.: Published by the Carnegie Institution. 1904.

structure of the sperms of the pteridophytes and the sexual processes in Onoclea, Cycas, Zamia, Ginkgo, Pinus, and for the angiosperms Helleborus and Lilium. Among these higher forms every month is bringing forth important papers and there are no cytological topics in which the ground has so frequently shifted and is still so unstable as that treating the events and significance of synapsis and heterotypic mitosis and the behavior of chromosomes during reduction and fertilization.

The work deserves special mention for its clear exposition of the chief theories of STRASBURGER on subjects associated with sexual reproduction. It is the most complete account of the speculations of this master published in English and should be very welcome to the general reader.

The book is very fully illustrated and the figures excellent, but they would have been even clearer if printed on a paper with a smoother surface.—B. M. DAVIS.

GUÉRIN[2] has brought together in a very useful way for French readers our information in reference to fertilization and associated phenomena in seed-plants. Spermatogenesis, oogenesis, and fertilization in angiosperms are first presented; and the same topics are taken up under gymnosperms, the Cycadales, Coniferales, and Gnetales being considered separately. In each case a brief historical résumé is given, and the references to recent bibliography are fairly complete, surprisingly so in the case of American publications. There are numerous illustrations, and the orderly presentation of topics makes the work very easy to consult. Of special interest in a work issued from GUIGNARD'S laboratory is the full presentation of "double fertilization." Brief concluding chapters deal with a comparison of angiosperms and gymnosperms as to the origin and development of the reproductive structures and the phenomena of fertilization, a comparison of the phenomena of fertilization in plants and animals, and a general interpretation of the phenomena of fertilization. The work is a compact organization of current knowledge, and should be of great service in calling the attention of French botanists to the more modern points of view in connection with seed-plants.—J. M. C.

Botany among the ancient Greeks.

WHILE ALL botanists have heard of THEOPHRASTUS, and know that he wrote a treatise on plants, it is safe to assume that only a few have taken the time to read him in the original. We have had translations of his Ἱστορίαι τῶν φυτῶν, but now for the first time there is before us a critical study of this work, as well as the works of other Greek and Roman writers.[3] It appears that the stimulus for the Ἱστορίαι was largely given by the reports brought back from India by those who accompanied Alexander the Great upon his journey of conquest.

[2] GUÉRIN, PAUL, Les connaissances actuelles sur la fécondation chez les Phanérogames. pp. vii + 160. Paris: A. Joanin et Cie. 1904. 10 *fr.*

[3] BRETZL, HUGO, Botanische Forschungen des Alexanderzuges. 8vo. pp. xii + 412. *figs. 11. maps 4.* Leipzig: B. G. Teubner. 1903. *M* 12.

The original reports of the officers of this expedition are lost to the world, perhaps forever, but THEOPHRASTUS had access to them, and has presented their observations on plants, together with his own. BRETZL, the author of the work, believes that THEOPHRASTUS deserves to rank among the great botanists of the world, and that he was the only great botanist of antiquity, so far as we have record. PLINY, in comparison, is regarded as an inaccurate copyist. It is certainly remarkable that at the very earliest dawn of botanical study so many correct observations should be made, observations, too, which have commonly been lost sight of even until now. Nearly all of the important observations made by THEOPHRASTUS have been reported as original by modern botanists.

A few of the more striking contributions made by the Greeks may be here mentioned. Mangrove swamps were reported about the Persian Gulf, and this record is the only one we have of them; they have not yet been "originally" reported by modern botanists; SCHIMPER says that, with the exception of Avicennia, mangroves have not been seen west of the Indus. The descriptions of the mangroves are so exact that one has no trouble in making out the character species as we now know them. The zonal relations of the species were noted, Rhizophora being correctly regarded as the pioneer. It was inexplicable to them, as it is to us still, that plants, and particularly trees, could grow in salt water. Similar geographic studies were made in the deserts of Beluchistan, and there, as in the mangrove swamps, the character plants were described as such. THEOPHRASTUS used a series of leaf types in his descriptions, based largely on ecological features; more than two thousand years later, HUMBOLDT made out a similar series, and largely because of this has been generally regarded as the father of plant geography. The nyctitropic movements of the tamarind leaf are carefully described and are definitely termed sleep movements, distinction being made between leaves of that type and those of Mimosa. The banyan is correctly regarded as a fig, and the supporting roots are called roots and not stems, because they are leafless, and not green; their adventitious character is also noted. Compound leaves are so regarded in spite of the leaf-like appearance of the leaflets; the reasons given are the fall of the entire structure in autumn, and the fact that in the buds the leaflets are not differentiated. The sexuality of plants is clearly shown, especially in cucurbits and dates, and use is made of the terms male and female. Nearly two thousand years later, CAMERARIUS again showed the sexuality of plants, although it was late in the century just past before it was universally accepted.—HENRY C. COWLES.

Biological statistics.

DAVENPORT'S *Statistical methods*[4] has been revised and enlarged and made to embody all the more important recent developments in the mathematical analysis of variation in living organisms, as elaborated chiefly by PEARSON and

[4] DAVENPORT, C. B., Statistical methods with special reference to biological variation. 2d. ed. 16mo. pp. viii + 223. *figs.* 10. 1904. New York: John Wiley & Sons. For review of first edition see BOT. GAZ. **28**: 364. 1899.

his students. Much of the book has been rewritten and many additions of new examples and new methods are given, making it more indispensable than ever as a handbook for the student of this important phase of biology.

The changes which have been made are too numerous to be considered in detail, but the most noticeable are as follows. (*a*) The section is omitted which dealt with the quantitatve expression of terms used by botanical taxonomists in the description of leaf-form. (*b*) The subject of correlation has received new and altogether better treatment by the substitution of YULES's method for DUNCKER'S, and the addition of PEARSON'S method for determining the correlation between qualities not quantitatively measurable. (*c*) Two additional types of asymmetrical curves are presented. (*d*) A section is introduced dealing with MENDEL'S law of alternative inheritance. (*e*) A 22-page chapter on the results of statistical biological study is substituted for the 2-page chapter on the applications of statistical methods. (*f*) A professedly complete bibliography is given instead of a selected one.

A comparison of the bibliography with that given in the first edition shows in an interesting way the remarkable activity which has developed in this field. In the earlier edition thirty-nine titles were given, in the present edition there are 265 references, 186 of which bear dates later than the date of publication of the first edition. As is usual in extensive bibliographies the attempt at completeness leaves something to be desired. A number of titles not found in the list occur to the reviewer as being of more value statistically than some which are given.

The unique feature of the chapter on the results of statistical studies is a tabulated analysis of the literature, showing the general bearing, and in some instances the point of view, of each paper. At least two of these papers are listed under subjects to which they make no significant contribution; *e. g.*, HARSHBERGER on "The limits of variation in plants" and KELLERMAN on "Variation in *Syndesmon thalictroides*" are classed as dealing with correlation, but neither paper treats specifically of questions of correlation, and the data given by each are too meager to be of value to students who would be interested in turning them to account in the study of correlations.

Everyone will appreciate how difficult it must be to keep free from errors a work made up so largely of tabulations. A reference on p. 113 to Table X means Table X of the first edition, which has become Table XII of the present edition. Botanists will be astonished to see *Syndesmon thalictroides* classed as a desmid on p. 78.

On the whole, the second edition is a very marked advance over the first, and there is every reason to expect that with its assistance the bibliography of statistical biology will rapidly advance in the coming years, not alone in the number of titles but also in the clearness and completeness of mathematical analysis and in the importance of the conclusions reached.—GEORGE H. SHULL.

Gasteromycetes of Hungary.

HOLLÓS'S[5] imposing monograph of the Gasteromycetes of Hungary, the German edition of which has recently come from the press, will form one of the most valuable additions to the literature of this group. One cannot read the introductory parts of this work without feeling that the most careful and critical attention has been given to every detail.

In 1896 the author, as he tells us, began to devote exclusively to the study of the gasteromycetes the time that his duties as teacher in the Staatsoberrealschule in Kecskemét left at his disposal. From this time until the completion of the work material was collected principally by innumerable excursions into the various parts of Hungary, while many specimens were received from collectors throughout the country. By purchase or exchange the author was able to secure numerous types from other European countries and from America, thus making possible a direct comparison of specimens representing species common to these countries. The scope of the study was still further widened by visits to all the important collections of gasteromycetes in Europe.

In the work, which is a large folio volume, eighty-one species and many varieties are described and illustrated. These represent all the forms known to occur in Hungary. To the technical descriptions the author has added his own observations, both adding to the original description and pointing out many peculiarities of appearance or form occurring during the different stages of the growth of the plants. These incidental characters, that are too often omitted in descriptions, bring to the mind a clearer picture of the plant in question than the categorical enumeration of technical characters. The text includes complete citations of specimens seen by the author, enabling the future student to identify the plants which the author had in mind or his descriptions and drawings. A full list of synonyms is found at the end of the descriptive portion.

The work contains thirty-one beautifully executed plates, printed by a color-type process from colored drawings and from colored photographs. In the illustrations the author has endeavored to represent specimens showing the different stages and forms in which the fungus is likely to be found. Variable species are more fully illustrated. Five plates are devoted to the forms of *Secotium agaricoides*. Microscopical details are added in most cases.

The complete descriptions, full synonomy and citations, and the excellent illustrations are three features that will insure this book a position of authority among taxonomic works. Not only will it be of value to the students of the country for which it was written, but also to American students, for most of the gasteromycetes have a world-wide distribution. Of the forms described nearly all occur in this country and specimens of many of these were seen and cited by the author. —H. HASSELBRING.

[5] HOLLÓS, LADISLAUS, Die Gasteromyceten Ungarns. Im Auftrage der ungarischen Akademie der Wissenschaften. Autorisierte deutsche Uebersetzung, mit Unterstützung der Ungarischen Akademie der Wissenschaften. Folio 30×42cm. pp. 279. *pls.* 31. Leipzig: Oswald Weigel. 1904. *M* 80.

Two recent books on algae.

A VERY readable text on British fresh-water algae by G. S. WEST[6] has appeared and will be welcomed as the only work of its kind in English that is up to date. The descriptive portions of the book are clear and the figures excellent. The accounts of the desmids, diatoms, and unicellular green algae deserve special mention. The general arrangement of the groups is quite simple and consistent from the author's point of view, but few specialists would be likely to agree with him, so varied are the classifications of the algae. WEST's arrangement is in the main conservative, and the synopses and keys are so clear that the reader cannot be confused. There is a preliminary account of methods of reproduction, sexual organs, polymorphism, and phylogeny. These topics might well have been expanded, as in their condensed form a reader with little knowledge of morphology is scarcely likely to grasp the underlying homologies and evolutionary principles illustrated in the algae.

Much more pretentious is a large volume of OLTMANNS[7] which is announced as the special part and is to be followed shortly by a second that will treat of general problems. OLTMANNS covers the entire group of the algae, fresh water and marine, excepting the Cyanophyceae, and aims to collect all important literature of recent years. His classification is elaborate, and the arrangement of the great groups is quite different from that in *Die natürlichen Pflanzenfamilien*. However, the families are easily understood, and it is around them that the descriptive matter is collected in convenient form. Reproductive processes are discussed in great detail, especially for the Phaeophyceae and Rhodophyceae, where the advance in our knowledge has been greatest in recent years. The account of the Rhodophyceae, following his interpretation of the cystocarp as involving a sporophytic generation associated with the gametophyte, is an especially valuable contribution, bringing order into what has been one of the most chaotic subjects in botany. The work is very full of figures, some 470, excellently reproduced, many of them covering the greater part of the page. This first volume is sure to find a hearty reception and the second one will be awaited with keen interest.—B. M. DAVIS.

Index Bryologicus.

THE *Index Bryologicus* of Général PARIS[8] was completed in 1894 and a supplement was published in 1900. It was welcome as a real boon to bryologists and the immense toil of its author was gratefully appreciated. Now it has been

[6] WEST, G. S., A treatise on the British freshwater algae. 8vo. pp. 372. *figs. 166*. Cambridge University Press. 1904. 10s. 6d.

[7] OLTMANNS, F., Morphologie und Biologie der Algen. Vol. I. 8vo. pp. 733. *figs. 467*. Jena: Gustav Fischer. 1904. *M* 20.

[8] PARIS, E. G., Index Bryologicus sive enumeratio muscorum ad diem ultimam anni 1900 cognitorum, adjunctis synonymia distributioneque geographica locupletissimis. fasc. II. 8vo. pp. 65–128. Paris: Librairie Scientifique A. Hermann. 1903 2.50 *fr*.

determined to recast the work and to supply certain deficiencies, especially in dates of publication and in Scandinavian literature, bringing the work down to the beginning of the twentieth century as a point of departure for future investigations.

The original was unfortunate in usually omitting the dates of publication of species; the prospectus announces that in the second edition this lack will be supplied. Yet the second fascicle (which alone has just reached us) shows many failures to carry out this laudable intention. *Nomina nuda* (admitted in the first edition in hope of proper publication!) will be rigorously excluded, it is said, but the *Index* will include besides described species and those issued in numbered exsiccati, species "existant dans les grands herbiers publiques (Kew, British Museum, Paris, etc.) où on peut les consulter." The latter have no place in such a work and should be as rigorously excluded as other *nomina nuda*.

The author of so important a bibliographical work should have adopted a consistent system of citation and adhered to it rigidly. Much space might have been saved and greater clearness attained by attention to such details. References "*loc. et op. cit.*" are maddening because they compel the users to hunt back for the last citation often some lines back and not prominent enough to catch the eye readily. Even with its faults the revision of this indispensable *Index* will be greatly appreciated. We trust the publisher will take due pains to make its dress accurate and worthy of this valuable work. It is to be issued in monthly fascicles of which about 25 will be needed.—C. R. B.

Wiesner and his school.

THE PERSONALITY of a great investigator is very properly recognized upon festal days by his associates and pupils. Hofrat Professor Dr. WIESNER founded in 1873 the institute for plant physiology in University of Vienna, and upon the occasion of the thirtieth anniversary of his professorship his many pupils have united in congratulations, and a *Festschrift*[9] has been prepared by three of them, which takes the form of a contribution to the history of botany. After a congratulatory introduction by Dr. HANS MOLISCH it consists of two parts. In the first is a bibliography of WIESNER'S writings, which number 213 titles extending over fifty years (1854–1903), and a running summary of his contributions to various subjects, classified so as to facilitate ready reference. As a second part there is a bibliography of 157 titles and a similar résumé of the work by his pupils which has issued from this institute. The first part was prepared by Dr. LUDWIG LINSBAUER of the Imperial Gymnasium and Dr. KARL LINSBAUER of the Institute (Professor Wiesner's assistant), and the second by Count LEOPOLD VON PORTHEIM, of the Biologische Versuchsanstalt recently established in the Prater.

[9] LINSBAUER, K., LINSBAUER, L., and PORTHEIM, LEOPOLD R. VON, Wiesner und seine Schule; ein Beitrag zur Geschichte der Botanik. Festschrift anlässlich des dreissigjährigen Bestandes des pflanzenphysiologischen Institutes der Wiener Universität. Mit einem Vorwort von Prof. Dr. HANS MOLISCH. 8vo. pp. xviii + 260. Wien: Alfred Hölder. 1903.

Among the names in the second bibliography one finds those of BURGERSTEIN, CZAPEK, FRITSCH, HABERLANDT, KRASSER, LINSBAUER, MIKOSCH, MOLISCH, WETTSTEIN, ZAHLBRUCKNER, and others—certainly a notable list. It has been a pleasure to many American botanists to meet Professor WIESNER this summer and to join in the congratulations upon his past labors and extend to him our best wishes for the future.—C. R. B.

MINOR NOTICES.

FRITSCH has published an interesting contribution to the comparative morphology of the seedling of Gesneriaceae.[10] The account is so largely a description of many forms that a satisfactory summary is difficult to give. The book is divided into two parts. In the first part twenty-six species, comprising fourteen genera, are treated, and the gross form, particularly in several species of the Streptocarpus, is described in considerable detail. In the second part the structure of the grown plants is considered, and the behavior of the cotyledons, leaf arrangement, anisophylly, and kindred topics presented by this group are discussed. A chapter is devoted to a short account of the anatomy of Gesneriaceae and one also to the structure of Steptocarpus as compared with other Cyrtandroideae.—W. B. MACCALLUM.

THE HORTICULTURAL SOCIETY of New York has published[11] the proceedings of the International Conference on plant-breeding and hybridization held in New York city, September 30 and October 1 and 2, 1902. The conference was such a notable one in the quality of the papers presented that it is a valuable service to biology in general to have them accessible. Not only are the presented papers published, but also the discussions and the papers read by title. Forty-two papers are thus brought together, most of them dealing with the fundamental principles of plant-breeding and hydridization, and they represent investigations and conclusions that botanists should become more familiar with.—J. M. C.

LINDAU[12] has published a pocket handbook for the collection and preparation of the lower cryptogams with special reference to conditions in the tropics. In this work of some 75 pages the characteristic habitats of mosses, liverworts, algae, and fungi are described; directions are given for the preparation of material in herbarium form and for the simpler methods of preserving in spirits or in formalin. It is a book which the traveler and collector with botanical interests will find very useful.—B. M. DAVIS.

[10] FRITSCH, K., Die Keimpflanzen des Gesneriaceen, mit besonderer Berücksichtigung von Streptocarpus, nebst vergleichenden Studien über die Morphologie dieser Familie. 8vo. pp. iv+188. *figs.* 38. Jena: Gustav Fischer. 1904. *M*4.50.

[11] Proceedings International Conference on plant breeding and hybridization. 1902. Hort. Soc. N. Y. Memoirs, Vol. I. New York: Horticultural Society. 1904.

[12] LINDAU, G., Hilfsbuch für das Sammeln und Präparieren der niederen Kryptogamen mit besonderer Berücksichtigung der Verhältnisse in den Tropen. 12mo. pp. 78. Berlin: Gebrüder Borntraeger. 1904. *M*1.50.

THE TWENTIETH part of ENGLER'S *Das Pflanzenreich* is a presentation of the great tropical family Zingiberaceae by SCHUMANN.[13] The usual critical discussion of the family from various standpoints is followed by a presentation of the 38 genera and 849 species. Four new genera (*Odontychium*, *Gagnepainia*, *Aframomum*, *Monocostus*) and 141 new species are described.—J. M. C.

ROTH'S *Europäischen Laubmoose*[14] progresses rapidly, the eighth part having been issued in July and the ninth in October. They contain the conclusion of the Acrocarpae and a good share of the Pleurocarpae. It would seem that two more parts might complete the work. The author would do well to devote a final part to keys to genera and species.—C. R. B.

THE SECOND fascicle of the third volume of HALÁCSY'S[15] flora of Greece completes the work, including from Gramineae through the pteridophytes. With this last fascicle appear the general preface, the bibliography, an introduction describing the floristic regions, and a good index.—J. M. C.

NOTES FOR STUDENTS.

BESSEY[16] has described the peculiar stomata of *Holacantha Emoryi*, a leafless shrub of the southwestern arid regions. The guard cells lie at the bottom of a narrow chimney-shaped cavity which extends above and below the epidermis, and consists of about eight vertical rows of cells.—J. M. C.

THE MORPHOLOGY and general histology of three Pacific coast algae are described in the last number of the Minnesota Botanical Studies:[17] *Callymenia phyllophora* by CLARA K. LEAVITT; *Endocladia muricata* by FLORENCE M. WARNER; and *Laminaria bullata* by OLGA MUELLER.—B. M. DAVIS.

RUSSELL[18] shows many photographic prints produced by contact or mere approximation of various woods with a sensitized plate in darkness. The amount of action varies greatly with different woods, exposures of thirty minutes to eighteen hours or more being required. The active agent seems to be H_2O_2, and probably the resin in the wood is the indirect cause.—C. R. B.

[13] ENGLER, A., Das Pflanzenreich. Heft 20. Zingiberaceae von K. SCHUMANN. pp. 458. Leipzig: Wilhelm Engelmann. 1904. *M* 23.

[14] ROTH, GEORG, Die europäischen Laubmoose. Leiferung 8, pp. 257–384. *pls. 21–30.* Leiferung 9, pp. 385–512. *pls.* 31–40. Leipzig: Wilhelm Engelmann. 1904. Each *M* 4. Not sold separately.

[15] HALÁCSY, E. de, Conspectus Florae Graecae. Vol. III. fasc. 2. pp. 321–520. Leipzig: Wilhelm Engelmann. 1904. *M* 6.

[16] BESSEY, CHARLES E., The chimney-shaped stomata of *Holacantha Emoryi*. Bull. Torr. Bot. Club **31**: 523–527. *pl. 24.* 1904.

[17] Minnesota Botanical Studies **3**: 291–308. *pls. 44–47.* 1904.

[18] RUSSELL, W. J., On the action of wood on a photographic plate in the dark. Phil. Trans. Roy. Soc. London B. **197**: 281–289. *pls. 11–18.* 1904.

SCHULZE[19] has investigated quantitatively the formation of arginin in various stages of the germination of *Lupinus luteus*. He finds it is produced entirely from proteid decomposition, probably through the action of erepsin, a protease. The facts adduced seem to support his contention that asparagin is a secondary product, because it is not formed *pari passu* with decomposition of proteids as arginin is.—C. R. B.

MOLISCH reports[20] an extraordinarily rapid autonomous movement of the leaves in *Oxalis hedysaroides* HBK., far exceeding the oft-described movements of *Desmodium gyrans*. In the latter the leaf completes its elliptical path in 85–90 seconds at a temperature of 35° C., while in the former the tips of the leaflets may sink at once 30–45°, or a distance of 5–15^{mm}, in a single second, though the movement may consume twelve seconds and be executed in a succession of six jerks, with a pause of about a second between. The recovery occupies about five minutes.—C. R. B.

THE RESULTS of SCHOUTE[21] on the histogenetic layers of *Hippuris vulgaris* have been called in question by KNIEP[22] who considers that SCHOUTE studied too few specimens and used unsuitable methods. From a renewed study of the growing point in a large number of stems of Hippuris, KNIEP concludes that the histogenetic layers of HANSTEIN correspond to the regions distinguished by VAN TIEGHEM, thus going back to the old accepted view. It is unfortunate for this theory that Hippuris is the only flowering plant in which the histogenetic layers of the stem are distinguishable.—M. A. CHRYSLER.

SCHIFFNER calls COKER sharply to account[23] for overlooking his characterization of Dumortiera as having rudimentary air-chambers and so misrepresenting him.[24] He contends that the obliteration of the air-chambers is not an adaptation to a moist habitat, as COKER suggested, nor dependent on exposure to light, as STEPHANI held. Observations in Java and the constancy of *D. trichocephala* and *D. velutina* under cultivation for twenty years in the Vienna botanic garden are adduced in favor of his view that the extent of development of the air-chambers is a fixed and hereditable character of each species.—C. R. B.

THE JOINTED structure peculiar to some genera of the corallines in the red algae has been studied by YENDO.[25] These regions of the plant are free from

[19] SCHULZE, E., Ueber die Argininbildung in den Keimpflanzen von *Lupinus luteus*. Ber. Deutsch. Bot. Gesells. **22**:381–384. 1904.

[20] MOLISCH, HANS, Ueber eine auffallend rasche autonome Blattbewegung bei *Oxalis hedysaroides* HBK. Ber. Deutsch. Bot. Gesells. **22**:372–376. *figs. 2.* 1904.

[21] See review in BOT. GAZ. **35**:144. 1903.

[22] KNIEP, H. Sur le point végétatif de la tige de l'*Hippuris vulgaris*. Ann. Sci. Nat. Bot. VIII. **19**:293–303. 1904.

[23] SCHIFFNER, V., Ueber Dumortiera. Hedwigia **43**:428. 1904.

[24] COKER, W. C., Dumortiera. BOT. GAZETTE **36**:225. 1903.

[25] YENDO, K., A study of the genicula of Corallinae. Jour. Coll. Sci. Imp. Univ. Tokyo **19**:—. [pp. 41. *pls. 1.*] 1904.

the lime which is deposited between the cells in all of the nodes. The form of the genicula are frequently of important taxonomic value and they present several types of structure, the pitted structure being described and figured. The pits are both lateral and terminal and consist of depressions which extend to the middle lamella where there is a lens-shaped thickening which, however, lies in the middle of the cavity and does not completely close the pit.—B. M. DAVIS.

MISS FORD[26] has published a somewhat detailed account of the anatomy of Psilotum. The plant is monostelic throughout, being protostelic at the base of the aerial stem and often siphonostelic above. In the aerial branches a central core of sclerenchymatous fibers is found, and throughout the phloem is poorly developed. The form is probably a reduced one, but the anatomical evidence does not relate it closely to any of the living Lycopodiales. There is closer resemblance to certain Lepidodendron forms; but the combination of sporangial and anatomical characters is closest to Sphenophyllales, as BOWER has suggested.—J. M. C.

THE DEVELOPMENT of sieve tissue in conifers has been studied by CHAUVEAUD,[27] who describes elements intermediate between sieve tubes and parenchyma occurring in the hypocotyledonary portions of *Abies Pinsapo*, though not found in the higher regions of the stem. These elements are succeeded by the primary phloem, and both are eventually squeezed to a flat mass by growth of the secondary phloem. In another paper[28] the same author shows that the double leaf trace in the genera Abies and Pinus is single in the leaf of the seedling, and in the course of ontogeny splits into two, that is the double leaf trace is a secondary formation.—M. A. CHRYSLER.

DENNISTON[29] finds in developing starch grains of various sorts an outer sharply defined layer of material next the plastid which takes up orange strongly from the safranin gentian-violet orange stain, while the body of the grain becomes bright violet. Grains partly digested by diastase show the orange-staining layer little affected, while the violet regions are much dissolved and orange-staining material appears in the corroded interior. DENNISTON interprets these reactions to mean that the outer layer is different from the rest (MEYER was able only in a few cases to find such a layer in potato starch) and, in harmony with TIMBERLAKE'S study of the developing cell wall, believes it to be a carbohydrate not yet fully polymerized to starch.—C. R. B.

[26] FORD, SIBILLE O., The anatomy of *Psilotum triquetrum*. Ann. Botany **18**: 589–605. *pl. 39*. 1904.

[27] CHAUVEAUD, G. Le liber précurseur dans le sapin pinsapo. Ann. Sci. Nat. Bot. VIII. **19**: 321–333. 1904.

[28] CHAUVEAUD, G. Origine secondaire du double faisceau foliare chez les sapins (Abies) et les pins (Pinus). *l. c.* 335–348.

[29] DENNISTON, R. H., The structure of the starch grain. Trans. Wis. Acad. **14**: 527–533. 1904.

FROM A series of experiments in which the radicles of seedlings were employed as physiological reagents, DANDENO[30] concludes that the theory of electrolytic dissociation is without support from the physiological side. The author also finds, as TRUE and OGLEVEE have already shown,[31] that the toxic effect of certain solutions is greatly reduced by the mere presence of non-chemical bodies, such as pure sand whose property of physical affinity retards chemical action and physiological effect. The economic significance of these facts is also stated. Other factors regarded as affecting toxicity of solution are quantity of solution, rate of diffusion, shape of container, and even the glass walls of the container. —RAYMOND H. POND.

TWO NOTES of interest in relation to the way in which the powdery mildew and downy mildew live through the winter are published by ISTVÁNFFI.[32] As is well known the perithecia of the powdery mildew rarely occur in Europe, and according to the author they have not been found in Hungary. Patches of mycelium, however, are said to remain alive during the winter on the stems and dried clusters of grapes left on the vines. From these fresh conidia were produced when taken into the laboratory in January. Similar observations, the author states were made by APPEL. The mycelium of the downy mildew is also found[33] to survive the winter in parts of the vine, especially in the buds, thus confirming the observations of CULONI.—H. HASSELBRING.

TO ASCERTAIN the influence of a periodical dry season upon the meristematic activity of the cambium, URSPRUNG[34] has studied the anatomy of certain species common to Buitenzorg and East Java. The climate of the former locality is uniform, while that of the latter shows a distinct periodicity of wet and dry seasons. He finds as a general rule (for representatives of six different families) that material from East Java shows a much more complete and distinct zonation of wood structure than specimens of the same species from Buitenzorg. Species vary, however, in susceptibility to climate, since the one which shows the relatively clearest zonation in Buitenzorg may not sustain this relation in a group of the same species from East Java. The influence of foliation and defoliation upon

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[30] DANDENO, J. B., The relation of mass action and physical affinity to toxicity, with incidental discussion as to how far electrolytic dissociation may be involved. Amer. Jour. Sci. IV. **17**:437–358. 1904.

[31] TRUE, R. H., and OGLEVEE, C. S., The effect of the presence of insoluble substances on the toxic action of poisons. Science N. S. **19**:421. 1904.

[32] ISTVÁNFFI, GY. DE, Sur l'hivernage de l'oïdium de la vigne. Compt. Rend. Acad. Sci. Paris **138**:596–597. 1904.

[33] ISTVÁNFFI, GY. DE, Sur la perpétuation du mildiou de la vigne. Compt. Rend. Acad. Sci. Paris **138**:643–644 1904.

[34] URSPRUNG, A., Zur Periodicität des Dickenwachsthums in den Tropen. Bot. Zeitung **62**[1]:189–210. 1904.

the activity of the cambium is given some attention, but no general conclusion is established.—RAYMOND H. POND

SEVERAL METHODS in cytological technique are described by OSTERHOUT.[35] One of these is a substitute for the universally used paraffin method. Though various soaps have been tried and found unsatisfactory, OSTERHOUT has developed a method with cocoanut oil soap which he regards as superior to the paraffin method. It is better to make one's own soap, using 70^{cc} of cocoanut oil to 38.5^{cc} of 28 per cent. solution of caustic soda in water. The tissue is placed in warm water and the soap added gradually until a fairly strong solution is obtained. It may then stand in the bath for two or three days. When sufficiently firm, the block may be cut. The sections form a perfect ribbon and do not crumble or crush as is so often the case with paraffin. They may be fixed to the slide with albumen. In trying this method one should have the full paper at hand.—CHARLES J. CHAMBERLAIN.

THE GREAT and, indeed, almost violent interest taken in some quarters in Bulletin 22 of the U. S. Bureau of Soils, will cause the appearance of Bulletin 23 to arouse some curiosity at least.[36] The subject-matter of the present bulletin falls into two separate portions. The first presents a series of rather incomplete experiments on the movement of soil water, together with some data on the rate of imbibition of seeds in contact with moist soil, while the second portion deals with experiments on the growth of plants in culture media. The first mass of material is not important, but the second presents a discovery which, if substantiated and generally true, is as far-reaching and important as it is unexpected. This discovery is, briefly, that the good or bad characteristics of a soil are transmitted to its aqueous extract. This is shown by growing wheat plants in pots of the soils to be compared and in bottles of watery extract of these same soils. In such an experiment the different water cultures show the same relations as do the pot cultures. The plants were compared in respect to size and general appearance and to amount of transpiration. That this difference in soils and their solutions is not one of mineral salts is shown by the fact that good and poor Cecil clay show the difference markedly, although practically identical in chemical nature. It is suggested that the bad properties of at least some sterile soils may be due to organic substances. The bulletin is essentially a report of progress and all of its lines of investigation will need further work before they can be regarded as established.—B. E. LIVINGSTON.

[35] OSTERHOUT, W. J. V., Contributions to cytological technique. (1) A simple freezing microtome. (2) Fixation *in vacuo*. (3) A simple slide holder. (4) A rapid method of mounting in aqueous media. (5) Embedding microscopic algae. (6) Embedding with incomplete dehydration. Univ. of California Publications. Botany **2**:73–90. 1904.

[36] WHITNEY, M. and CAMERON, F. K., Investigations in soil fertility. U. S. Dept. Agric., Bureau of Soils, Bull. 23. 1904.

MISS MATTHAEI[37] has made a careful study of the effect of temperature on photosynthesis, which by avoiding radical sources of error corrects the resul s of various observers and particularly those of KREUSSLER, which have been accepted and quoted for more than a decade. Having found that the actual temperature of a leaf was not that of the water bath within which it was placed when high intensity of light was used, thermoelectric measurements of temperature became necessary. A thermocouple of copper and constantan wires only .087 mm in diameter was imbedded in the midrib of the leaf used and was connected with a galvanometer to which also a second thermoelement in a water bath was connected. When this bath was brought to such a temperature that there was no deflection of the needle the temperature of the element in the leaf was known. The results show that corresponding to each temperature there is a definite maximal amount of photosynthesis which cannot be reached unless both light and CO_2 supply are adequate. These maxima increase with increasing temperature, forming a curve convex to the temperature abscissas which resembles the respiration-temperature curve. They begin to decrease suddenly some degrees below the temperature which can be endured only a few hours. The maximum photosynthesis at any temperature can be maintained only for a short time, declining the sooner the higher the temperature. The difficulties overcome in the experimentation and the manipulative skill exhibited make this a notable contribution to plant physiology.—C. R. B.

KUYPER[38] has given an account of the events of the development of the ascocarp of *Monascus purpureus* Went and *M. Barkeri* Dangeard. The account of the former agrees in the main with that recently given by IKENO,[39] but differs in some respects. The sequence of events is as follows: The ascogonium consists of two cells, the lower of which develops. No fusion was observed between the ascogonium and pollinodium. The number of nuclei in the ascogonium increases. "Free cells" are then formed possessing one to several nuclei. The 1-nucleate stage is regarded as having arisen from the fusion of the nuclei of the originally binucleate cell, a view opposed to that of IKENO, who believes the cells to appear with single nuclei. In the next stages the number of nuclei in each free cell increases to a considerable extent. It appears that the spores are now formed within the free cells. These are represented as containing a variable number of nuclei, one to many, so that the whole spore is deeply stained. According to IKENO each spore contains but a single nucleus while the other nuclei of the free cell degenerate. When mature the spores fall apart and come to lie free in the

[37] MATTHAEI, GABRIELLE L. C., Experimental researches on vegetable assimilation and respiration. III. On the effect of temperature on carbon-dioxide assimilation Phil. Trans. Roy. Soc. London B. **197**:47–105. *figs. 6.* 1904.

[38] KUYPER, H. P., De perithecium-ontwikkelung van *Monascus purpureus* Went en *M. Barkeri* Dangeard in verband neet de phylogenie der Ascomyceten. Dissertation. pp. 148. Amsterdam. 1904.

[39] IKENO, Ueber Sporenbildung etc. Ber. Deutsch. Bot. Gesells. **21**:259. 1903.

ascogonium. The account of *M. Barkeri* follows the same general outline with some differences as to details. The protoplasm of the ascogonium is divided into sections by irregular vacuoles. These sections become free cells within which the spores are formed. In the summary one spore is said to be formed from each of the eight nuclei in the free cell; in the text, however, the spores are described as possessing many nuclei. The paper contains also a long discussion of the Hemiasci and the phylogeny of the ascomycetes.—H. HASSELBRING.

NATHANSOHN[40] continues his investigations of the nature and functions of the plasmatic membrane in plants. The following points are now announced. If slices of Dahlia tubers be placed in 2 per cent. $Na_2S_2O_3$ solution for two days, they absorb the salt to such an extent that at the end of the experiment its concentration within the tissues is about one-sixth of that without. If now these slices be changed to a solution of the same salt of a concentration equal to that now within the tissue, there occurs a marked outward diffusion, so that at the end of another two days the inner concentration is considerably less than one-half of the outer one. This means, of course, that the salt has passed through the plasmatic membrane in a direction from the weaker to the stronger solution, *i. e.*, against its own diffusion tension. This case substantiates similar results already published by the same author.

Furthermore, slices of the tubers of *Helianthus tuberosus* and of the roots of the red beet placed in solutions of NH_4Cl, NH_4NO_3, $(NH_4)_2S_2O_3$, $(NH_4)_2SO_4$, and $(NH_4)_2HPO_4$, absorb much more of the ammonium ion than of the anion. This is not accompanied by an increasingly acid reaction of the external solution. The last observation led to an investigation of the substances which might diffuse out from the cells, and enough Mg was found to have escaped to account for about three-fourths of the NH_4 which had entered. The author supposes that some other cations, perhaps in part organic bases, must be given out from the cells, and thus explains the lack of acidity. It is possible also to cause the extrusion of Mg by subjecting these tissues to a solution of a potassium salt. K is absorbed and Mg replaces it in the external solution.

A very interesting theoretical discussion makes up a good part of the paper, in which the nature of the protoplasmic layers is considered in the light of the new facts, but this cannot be entered into here.—B. E. LIVINGSTON.

BRIGGS and MCCALL[41] have devised an ingenious method for investigating soil solutions and the rate of movement of such solutions in the soil. The apparatus consists, briefly, of a porous porcelain filter tube connected with a vacuum chamber. The wall of the tube is saturated with water, and in this condition it can be exhausted to the vapor pressure of water, and will maintain this nearly

[40] NATHANSOHN, A., Weitere Mitteilungen über die Regulation der Stoffaufnahme. Jahrb. Wiss. Bot. **40**: 403–442. 1904.

[41] BRIGGS, L. J. and MCCALL, A. G., An artificial root for inducing capillary movement of soil moisture. Science N. S. **20**: 566–568. 1904.

complete vacuum against atmospheric pressure for a day or more. The tube thus prepared and connected to a two-liter vacuum chamber is placed in the soil to be studied. The water surfaces of the pores in the tube become continuous with the surfaces of water films in the soil, and water moves into the tube at a rate which varies with the nature of the soil and its amount of contained moisture. The force involved in the movement of water through the wall of the tube is the difference between the capillary pressure or surface tension of the water surfaces at the external and internal ends of the pores of the wall. And since the external surfaces are continuous with those of the soil water, it follows that water must pass from the soil into the tube, for the soil films are subjected to a pressure of one atmosphere, while those at the internal surface of the tube bear a pressure only equal to the vapor pressure of water. The authors do not make this matter immediately clear, and it may simplify matters to call attention to the fact[42] that the films of tube and soil form a system one extremity of which (in contact with the vacuum) is subjected to a very low pressure, while the other extremity (in contact with the air) is subjected to a pressure relatively very great. Thus in the end the solution is driven through the tube by atmospheric pressure, though the steps in the movement involve the forces of capillary films.

The rate at which water collects in the tube is the criterion for the soil's power of delivery. The authors state that the nature of the collected solution is the same as that of the soil itself, though proof of this is reserved for a later paper.—B. E. LIVINGSTON.

ERIKSSON[43] has published two further accounts bearing on the mycoplasma theory of rust fungi. These accounts deal with *Puccinia dispersa* Eriks. on rye and *P. glumarum* Eriks. & Henn. on barley. The facts, according to the author, are these. The teleutospores of *P. glumarum* are capable of germinating immediately after ripening in midsummer. Aecidia occur on *Anchusa arvensis* and *A. officinalis*. During thirteen years' observations the aecidia were observed only in three instances in the vicinity of Stockholm. Both because the aecidium is produced from the teleutospores in summer or autumn, and on account of its rare occurrence in this region, it cannot be the source of spring infections of rye. It is also impossible to find living mycelium in the plants during the winter. These facts point to the conclusion that the infection arises from a germ already existing in the seed. In the leaves sectioned during the winter the author found peculiar dense protoplasm which he considers as a mixture of the protoplasm of the host and of the fungus mycoplasm. Later the nucleus is partially dissolved, while "nucleoli" begin to appear in the mycoplasm. This stage occurs immediately

[42] This method of statement has been hinted at in a review of this article by KING. Either this reviewer has failed to grasp entirely the meaning of the authors or his own statements are so ambiguous as not to warrant a discussion of his criticisms here. See KING, F. H., An artificial root for inducing capillary movement of soil moisture. Science N. S. **20**:680–681. 1904.

[43] ERIKSSON, J., Ueber das vegetative Leben der Getreiderostpilze. Kungl. Svensk. Vet.-Akad. Handl. **38**:—. [no. 3. pp. 18.] *pls.* 3. 1904.

before the appearance of uredosori. In the next stage intercellular protomycelium begins to appear. The patches of mycelium are connected with the "nucleoli" mentioned above. These are the centers of development for the intercellular mycelium. The course of development of *P. glumarum* follows the same lines.

Some of the author's figures admit of a different interpretation from that given. It is difficult to see how a nucleus being dissolved by a substance diffused throughout the cell as the mycoplasm would be can be cut away on one side in such an abrupt way as figured in *pl. 1*. It would seem possible that the protoplasmic connections extending from nucleoli to the intercellular protoplasm represent haustoria, for, to use the author's own words, they give exactly the same impression as a young haustorium of the Uredineae.—H. HASSELBRING.

THE REGULATION of turgor in molds is again the subject of study, this time by PANTANELLI,[44] working with Aspergillus. The author points out that, since in these organisms the cell walls are normally in a state of tension owing to the pressure within, the method of plasmolysis is not available directly as a measure of turgor pressure. Incipient plasmolysis will occur only after the application of an external pressure which is equal to the normal pressure of the vacuole plus that of the stretched wall. He further shows that the pressure which influences the wall is made up of at least three components: the osmotic pressure of the vacuole, the pressure of swelling of the protoplasm itself (*Quellungskraft*, closely related, if not identical with the pressure of imbibition in organic bodies), and the tension of the surface films. The latter is exerted toward the center of the cell, and is negligible when compared with the other two which are exerted in the opposite direction. An ingenious method for approximating these two outwardly directed forces is used in the work. It is based on measurement of cell shrinkage in plasmolyzing solutions. To control the results obtained by plasmolysis, the method of determining the freezing-point of expressed sap is resorted to.

Cells of this form live but a few days and practically all the cells of a culture die when spores are produced. Thus it is necessary to be sure one works with at least a great majority of living cells. The pressure of swelling decreases with age of the cell, while the osmotic pressure of the sap first rises and later falls, but is always dependent upon the pressure of the nutrient medium. The total turgor pressure of a cell depends in great measure upon conditions of nutrition, rising with increase of sugar in the medium, sinking with lack of oxygen. Other conditions, such as temperature changes, anaesthetics, etc., affect turgor pressure, and the author is convinced that in these changes we have a true response within the protoplasm itself. When the fungus responds to sudden increase in external osmotic pressure, its adjustment takes place at a rate which is related to the velocity of penetration into the protoplasm of the solute used. This leads to the idea that the perception of the osmotic stimulus occurs only when this solute has distributed itself throughout the protoplasm.—B. E. LIVINGSTON.

[44] PANTANELLI, E., Zur Kenntnis der Turgorregulationen bei Schimmelpilzen. Jahrb. Wiss. Bot. **40**:303–367. 1904.

NEWS.

PROFESSOR W. PFEFFER has been elected a corresponding member of the Vienna Academy of Sciences.

F. M. ROLFS has been appointed professor of botany and horticulture in the University of Florida, at Lake City.

R. S. WILLIAMS, who has been collecting in the Philippines for the New York Botanical Gardens, has lost his collections of four months by fire in a hotel where he was making his headquarters.

PROFESSOR N. L. BRITTON, director of the New York Botanical Garden, received the honorary degree of D.Sc. from Columbia University in connection with the recent celebration of the one hundred and fiftieth anniversary of its foundation as King's College.

BERNARD RENAULT, the well-known paleobotanist at the Museum of Natural History in Paris, died October 16, 1904, at the age of sixty-eight years. His studies of the conspicuous vegetation of the Coal Measures have been of the greatest possible service to anatomists and morphologists.

PROFESSOR W. A. KELLERMAN, of the Ohio State University, will spend the first three months of the coming year in Guatemala. He expects to traverse the country from east to west, and to spend considerable time in the Andes Mountains. The purpose of the trip is to collect parasitic fungi, and incidentally to execute some small botanical commissions.

THE FORMER students of Professor CHARLES E. BESSEY who are connected with the Office of Vegetable Pathology and Physiology, Department of Agriculture, have had an enlarged copy of his photograph framed and presented to the office. The portrait was unveiled by Dr. E. A. BESSEY, at a gathering of the office staff on November 28. Miss CARRIE HARRISON presented the picture, and appropriate remarks were made by Messrs. WOODS, WEBBER, and SHEAR.

GENERAL INDEX.

The most important classified entries will be found under Contributors, Personals, and Reviews. New names and names of new genera, species, and varieties are printed in **bold-face** type; synonyms in *italics*.

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